Vol. XXII No. 4 Whole No. 186

APRIL, 1922

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers
Publication Office, Mount Morris, Illinois
CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois under the Act of March 3, 1979

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CLASS ROOM MANAGEMENT AND INSTRUCTION IN VOCATIONAL AGRICULTURE.

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A DISCUSSION OF THE PROBLEMS AND PRINCIPLES IN HANDLING CLASSROOM INSTRUCTION IN VOCATIONAL AGRICULTURE.

Since vocational agricultural instruction is given in the public schools as an integral part of the course of study, we must deal with students, for the most part, in the class room, not individually but in groups. In classes in vocational agriculture twenty to twenty-five students can be simultaneously taught by one instructor.

The problems of class room management have to do with the effective treatment of this unit group of students. The teacher of agriculture, to have the right perspective, as he faces the problems of the class room, should have a background of training in educational psychology and in the general theory of education, so that he will not confuse *means* and *ends* in his usage of methods, devices, and principles of teaching and class room management. Dr. Bagley in his *Class Room Management*, says: "Fundamentally, the task of the school is to fit the child for life in civilized society." Under our vocational plans, we become more specific in agriculture and train for useful employment, those who are preparing for the work of the farm. These combined aims should be kept constantly in mind by the teacher, as he meets the problems of the class room.

DISCIPLINE.

From the moment the teacher of agriculture enters his class room to the time when the last student leaves, problems of relationships, control, discipline and teaching come thick and fast. Not the least of these problems is discipline. Discipline

must be maintained at any cost, else there is no teaching or learning.

The purposes of discipline are to maintain proper learning conditions and to train in proper habits making for good citizenship. The teacher's general attitude toward his fellow men will color his philosophy and practices relative to discipline. There is the total depravity theory which considers children naturally and fundamentally bad; the opposite theory which holds that children are naturally good; the recapitulation theory, explaining the conduct of children by race development; and the neutral theory, which holds that children are neither good nor bad, but like a blank white page, their lives are to be inscribed upon by the agencies of instruction and control. Whatever shade or blend of theories one may hold the teacher who succeeds in discipline combines an unalterable firmness, a genuine sympathy, an unwavering consistency, and a human kindness in a leadership that is sure and steady.

Good lesson planning and preparation, on the part of the teacher, a well organized curriculum of study, and a clear and definite assignment, engaging the pupil's time and thought help greatly in minimizing the problems of discipline. Class room discipline in vocational agriculture need not be military or formal, but orderly, respectful to constituted authority, physical and mental attitudes of attention conducive to learning and habits of prompt dispatch of the business in hand, should be maintained. The teachers and pupils should know and realize that the whole force of the American government is back of the authority granted to the teachers of the public schools.

Lesson Planning.

The making of a plan for the class room procedure depends upon the nature of the class exercise. The class work may be planned for a recitation, discussion, lecture, review, examination, supervised study, laboratory or field exercise. In any case the efficient teacher will have a definite plan. The making of lesson plans need not be a formal, routine matter, unnecessarily burdensome to the teacher. The simplest and most common sense procedure should be sought. Every plan for a class procedure, whether it be for one or many sessions has the following essential elements:

I. Title of teaching unit.
II. Aim.
III. Material to be used.
IV. Subject matter to be presented.
V. Method to be used.

The subject-matter to be taught should be organized by the teacher under definite teaching points. These may be committed to memory by the teacher, or noted inconspicuously upon cards or note-book in the hand of the teacher. It is very important to have the method of the recitation planned, in order to direct successfully the class room activities. Whether the method shall be primarily, *questioning, illustration, demonstration, supplying information, testing, criticisms* and *evaluations, laboratory work*, or *supervised study*, should be definitely determined beforehand by the teacher in making his plans.

Some Suggestions for the Class Recitation.

1. The periods of the recitations are the high points in the day. The recitation is the climax of all periods of preparation. It is the "zero hour," the time to "go over the top." It is the trysting place of souls. It is the delicate situation where the "band plays softly." It is a time to spend life blood and be spent. It is the climax of the theme. All this is an attempt to impress upon the teacher, the great importance of the recitation period, so that both teacher and pupils will come up to it with the best preparation possible.

2. The teacher should stand before his class in recitation. An old man or a tired woman may be justified in sitting down behind a desk to teach, but a young teacher with a group of live American boys and girls has little excuse for not standing up in an attitude of leadership and enthusiasm when teaching a class. The students also should maintain a proper physical attitude for learning. They should sit upright in a comfortable and natural pose of attention, and not loll about on table, chair or seat in a careless or indifferent position.

3. Teacher and pupils should depend as little as is consistent with the method of recitation used, upon the text-book as possible. It may be necessary for the teacher to have notes to which he should refer in conducting the recitation, but in most discussion types of recitation it is highly desirable to become as free from the text-book as possible. The text-book imposes a barrier between the teacher and his class, as the manuscript of a lecturer prevents the best flash of eye to eye in giving his message.

4. The teacher should strive to get into the proper democratic relationship with his class. He should be sympathetically conscious of the students' mental status. Only as he finds where his

students are can he help them to the position higher to which he would lead them.

5. Speak in a clear, strong voice. The tendency of a teacher's voice is to rise to rasping, nervous tenor, that makes for disorder and fatigue. The voice is one of the teacher's most valuable assets and its culture and control should be a part of the teacher's concern.

6. Be enthusiastic. This quality of personality in the teacher, as well as in the salesman or friend, is an inestimable one counting for success. Of what use to society is any spiritual or physical possession we have unless we are able to pass it on through use and service. Nothing so handicaps a capable and otherwise good teacher as a lack of enthusiasm. This quality or power is worth striving for and can be cultivated.

7. Avoid sarcasm. The best critics of personality as well as all students, agree that sarcasm is a cruel weapon resorted to by mighty poor teachers. One can be as firm as a rock and as kind as the Master without hurting through sarcasm. No good results ever come from this bad practice.

8. Watch objectionable mannerisms into which all teachers are likely to fall. The use of pet words, gestures, and grunts, repetition of answers, loss of temper, calling pupils' names before putting the questions, these and many others often come to be habitual mannerisms destructive of best teaching results.

9. Seek variety in the class recitation. Use the various devices adapted to the type of recitations available, and thus break the monotony which often grips the teacher's methods. In agriculture we have a wide choice of methods to use. There is the quiz, the written test, the drill, the lecture, the laboratory, the field trip, supervised study, the illustrative and demonstration type, stories from life, pictures, etc., all lending interest, variety, and zest to the recitation.

10. Make clear and definite assignments. The assignments for study may be made at the beginning, throughout the period, or at the end of the recitation, depending upon the nature of the work. At any rate the student should clearly understand what is expected, so that he will have the satisfaction of knowing when he has completed the preparation assigned. The use of the supervised study period makes it possible to follow up the assignment very closely and see that it is properly understood and done.

METHODS IN RECITATION.

We can do little more in this paper than to call attention to the various methods used in the class room in teaching vocational agriculture.

1. *The topical method.* Here the students may be assigned to give a written or oral report upon some small unit of the subject matter, such as, "The Use of the Fanning Mill," "Filling the Silo," "Care of Sow at Farrowing Time," etc. Without assignment to special topics the students may be called upon to recite from topics treated in the text-books. This method should not be used too often, but for the sake of variety and for giving pupils opportunity to make longer recitations than a question and answer method would provide.

2. *Question and answer method.* This is the time-honored method of our craft. The art of questioning is the fine art of our profession. Dr. Stevens, of Columbia University, in Contributions No. 48, discusses "The Question as a Measure of Efficiency in Instruction." She says that when the question and answer type of recitation is rightly used, it is more fruitful for the teaching process than any other method of instruction. She characterizes good questions as follows:

1. A good question should stimulate reflection.
2. A good question should be adapted to the experience of the pupils.
3 A good question should draw forth well rounded thought.

3. *The lecture method.* Because the high school teacher is likely to ape the methods of college instructors in lecturing to their classes, this method has been pretty generally condemned for use in the high school. A judicious teacher, using good sense and adaptability may profitably use this method of giving instruction occasionally. The teacher often needs to tell his pupils of information, new material, recent developments, etc., which could be brought to the pupils in no other way. Furthermore, it may be well to use the lecture method occasionally in order to give opportunity for the students to learn the art of listening, note-taking, and organizing what they hear.

4. *The problem method.* The problem method calls for deductive exercise. There is a problem set up or discovered, or a situation to be met. The pupils must clearly realize the problem in order to engage in deductive reasoning. The problem may be simple or complicated. In agriculture the problem usually emphasizes the doing of something. There is to be discovered from known conditions the best way of doing certain things, as

the use of limestone, the filling of a silo, the selecting of seed corn, etc. There must be a collection of facts, of data, bearing upon the problem. A principle must be discovered from the data at hand, which can apply to the solution of the problem. The problem should then be solved to verify the principle discovered. The question and answer method is best to use in developing the results from the problem method. Of course, the method is not complete in many agricultural situations unless it carries with it, the manipulative processes necessary to solve the problem involved.

5. *The written lesson.* For the sake of variety and for the opportunity to allow students to gather up, classify, and deliberately express their thoughts on a given topic, there is a place for the written lesson. It may serve also as a form of test by which the teacher may learn of the progress of the pupils as well as of the efficiency of his own instruction. The written lesson should not be given too often, and it should not be extended over more than one class room period. Occasionally, brief five- or ten-minute written exercises are valuable for concentrated effort and variety in class room recitations.

6. *The laboratory method.* This method of the class room recitation is of sufficient importance and difficulty to be taken up as a separate paper. For this discussion we may merely state the types of laboratory work advisable. (1) *Experiments.* (2) *Verifications.* (3) *Demonstrations.* (4) *Practicums.* The nature of the laboratory exercise used will, of course, depend upon the subject-matter and purpose of the recitation under consideration. In the fullest consideration of the laboratory method we should also include *field trips.*

7. *Supervised study.* This method is also of sufficient scope and difficulty to warrant discussion in a later paper.

8. *Combination methods.* Certain features of several of the above methods may well be used in a single recitation. A resourceful teacher, will know when to ask questions, when to tell facts, when to develop principles, when to ask or call for discussion of topics, etc., and several of these methods may be combined in one recitation. Dr. Storm, in *How to Teach Agriculture,* says there are three "T's" in teaching agriculture—*testing, teaching,* and *training.*

The vocational teacher may well test his work by the standard; "Where there is no learning, there is no teaching."

ENERGY RELATIONS OF DYNAMO AND MOTOR.

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The dynamo and motor are reversible; a d. c. dynamo may be operated as a motor and a d. c. motor may be operated as a dynamo.

This reversibility results not only from their similarity of construction but from the fact that in every operating dynamo the motor principle is likewise operative and in any operating motor the dynamo principle is operative.

The power driving a *dynamo* comes from some *external* prime mover, but the forces opposing the rotation of the armature are *internal.* We say that it requires more power to drive a dynamo when the external load is increased but it is not so obvious as when in lifting a weight with a plank as a lever we increase the weight lifted from (say) 50 to 100 lbs. The greater external electrical load of a dynamo results in greater internal forces opposing the rotation of the armature. The current which a dynamo delivers magnetizes both field magnet and armature and the mutual action of the two magnetic fields thus produced results in forces which oppose the external prime mover. This may be made more apparent perhaps if we use the two three-finger rules, the right hand for dynamo action and the left hand for motor action. Hold both arms in front of you, extend both forefingers away from you to represent the direction of the field flux, extend both middle fingers at right angles to the fore-fingers and to the right to represent the current flowing in the armature conductors, then you see that one thumb points upward and the other downward. The right thumb shows the direction in which the external prime mover is driving the armature conductor and the left thumb shows the direction of the internal motor forces acting upon the same armature conductor.

Thus we see that in the very act of getting more electrical power out of a dynamo there are established within the dynamo correspondingly greater forces opposing the driving power, causing an automatic increase in the mechanical intake of power. You cannot get something for nothing; energy is neither created nor destroyed; the electrical output of power of a dynamo cannot exceed its mechanical intake of power.

The driving forces of an *electric motor* are *internal,* although the power is obtained from an external generator, and the forces

opposing these driving forces are *external*, resulting from the mechanical load.

The forces opposing the rotation of a trolley car motor when the car is moving up grade are greater than when the car is moving on a level track and the motor takes in from the external generator a correspondingly greater power. Why should the same external voltage (say 550) send more amperes into the same motor? The answer is not apparent until you realize that the dynamo principle is operating in the motor.

The dynamo principle is: If a wire is moved so as to cut lines of magnetic force, an e. m. f. is generated in that wire. In a motor armature are conductors moving across magnetic flux, hence there must be an e. m. f. generated in the armature conductors. If we use the same two three-finger rules and point the thumbs up and both forefingers away from you, one middle finger points to the left and the other to the right. The left middle finger shows the direction of current actually flowing in the motor conductor and the right middle finger shows the direction of the e. m. f. generated in that conductor by dynamo action. Thus we see that the dynamo action in the motor armature opposes the flow of current in the motor. This opposition to the motor current is not an ohmic resistance; it is a counter voltage. Ohm's law, p. d. $=$ ir, is not true for an electric motor; the true formula is p. d. $=$ ir$+E_m$, where E_m represents this counter voltage. Since this counter voltage is produced by dynamo action, its magnitude is determined by speed of armature, intensity of flux and number of armature conductors. We now may show why the same voltage will send more amperes through the same motor at one time than another. If a 550 volt, 1-4 ohm motor on a level track is moving at such speed that its counter voltage is 544, the excess of 6 volts will send 24 amperes through the motor. As soon as the car strikes the up grade, the greater external mechanical resistance will immediately lessen the speed of the motor and its counter voltage will immediately lessen to some value less than 544 (say 540). The excess voltage which now becomes 10 will send 40 amperes through the motor creating sufficient internal driving force to move the car up hill.

Hence it is apparent that in the very act of getting greater mechanical work done by a motor, conditions are established which cause a greater intake of electrical power. You cannot get something for nothing; energy is neither created nor destroyed; the mechanical output of power of a motor cannot exceed its electrical intake of power.

THE USE OF LOCAL APPLICATIONS IN THE TEACHING OF PHYSICS.[1]

By S. E. Boomer,

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The subject of physics is elective in many schools. I suppose we are not unique in having pupils whose chief plank in their school platform runs about as follows: We hold it to be our sacred right and our patriotic duty with which no autocrat, be he high school principal or other authority, will be permitted to interfere, to find and to follow the line of least resistance through school. They have heard from former students in physics of the hard problems, difficult laws, laborious reports and they vote another ticket. Indeed, many earnest students fearing these difficulties and seeing no special need for the subject elect an easier course.

We may believe that physics is the most important subject in the curriculum. We may believe in it as strongly as we believe in the four gospels but if pupils in our school elect another route we have little opportunity to convert them to our faith. We could not argue, if we would, that physics offers a line of least resistance. Let us not try to popularize it by making it easy. I have little sympathy with those teachers who would try to sugar coat every lesson and avoid all difficulties in order to shield the dear boys and girls from real work.

I want my pupils to have some experience with accurate measurements. I want them to know something of the methods of science and have a high regard for its conclusions. I want them to understand that scientists are among the hardest workers, and that it is necessary for them to dig if they would accomplish anything worth while. But I should like to have them enjoy the digging.

It has been a pleasure to me to observe that teachers of physics are not ashamed to describe in our meetings and in Science and Mathematics the simplest piece of apparatus or give to their fellow teachers a most elementary device in teaching. It is because of this spirit among us that I presume to ask your indulgence while I relate some very simple but delightful experiences. Primarily most of us are not investigators except in the sense that we are seekers after the best methods of teaching our great subject. If we can find some way, however simple it may be, to make our teaching more stimulating, more invigorating, more

[1]Read before the Physics Section of the C. A. S. and M. T. at Soldan High School, St. Louis, Nov. 25, 1921.

attractive, more useful, or more practical without sacrificing any of its value it is well that we should pass it on. No doubt many of you in industrial centers have done far more than I have in the use of local applications. My hope is that these suggestions may be of some service to teachers in communities which have few industries.

Many teachers of physics in such communities do all their work in lecture or recitation room and laboratory. They do not realize that there is abundant and inspiring material outside. Our little city of 6,500 inhabitants is not an industrial center, but we find much more material than we can use in one class.

Seven miles out from town Mr. Charles Etherton installed a water ram at a spring to furnish water for his farm house and barn. We went over the hills to see this single application. The principle of the ram was discussed while we listened to the clicking of that one at the spring. We measured the amount of water flowing through the ram per minute, 14 pints, and the amount delivered to a trough at the barn per minute, 1 pint. Mr. Etherton gave us the distance from the ram to the house, 1,000 feet, and the elevation, 85 feet. He explained how water was delivered to various places by the operation of valves. We computed the amount of water delivered per day and the amount of work done. There is another spring near by. The class estimated the amount of water flowing from the two, the fall that could be obtained and decided that sufficient energy was available to furnish electricity for the home. As we walked back up the steep, rocky path Mr. Etherton remarked, "For forty years my mother walked up this old rocky path in dry seasons with a kid in one arm and a bucket of water in the other hand." The boys and girls gained a better appreciation of this one application than I could possibly have given them with our pretty little glass model in the laboratory. Here was physics acting as a labor saver, not a labor maker.

Our genial host took us to his fine orchard and told us of an interesting example of air drainage and frost. The east side of the orchard sloped rapidly down into a woodland which continued to a ravine far below. One year all the apples in the lowest row were destroyed by frost. On the next row only those at the very top were left. Farther up the slope only the lower half were destroyed, then only those on the lower branches were claimed by the frost. Above this row all the trees hung heavy with Winesaps and Johnathans. I asked him to let the class

work out the explanation. They did so with much more interest than I have been able to secure with the best book problems.

Ayer and Lord have in Carbondale the largest tie preserving plant in the world. Several times I have asked the superintendent for the privilege of having my classes visit the plant. It has always been granted gladly and a foreman has given his time to show us through and explain to a fascinated class the various operations. We saw many pumps, large and strongly built. Our glass models have their value but here the class saw one pump compressing air and steam at 180 pounds to a square inch into a cylinder 120 feet long and 8 feet in diameter, another exhausting the steam and air from a similar cylinder, a third forcing the creosote into the pores of seven hundred ties in a third cylinder of like dimensions with a pressure of 150 pounds to the square inch (Pascal's Law). They observed a train of little cars loaded with ties being pulled into another big cylinder by electric motor. The ties were bound down for, by Archimedes' principle, they would float in the liquid.

The foreman called our attention to a hydraulic press he had made for forcing the little car wheels on the axle, the hole in the wheel being three thousandths of an inch less in diameter than the axle. The press had thick walls capable of sustaining a force of thirty tons which may be exerted by the machine. Another example of Pascal's Law.

The method of heating the creosote furnished a fine application of convection. Two tanks twelve feet long and one foot in diameter were mounted below the 23,000 gallon creosote tank at an angle of about 45 degrees with the vertical. Through each of these passed pipes 158 feet long wound into coils carrying steam under high pressure. The lower ends of the small tanks were attached to the bottom of the big tank and the upper ends to points near the top of the latter. The foreman told us that when the hot steam was flowing through the coils the creosote flowed through these small tanks faster than any pump could force it through.

We observed hastily their big engines, dynamos, motors and other applications of physics. Time did not permit a discussion of these. A happy class returned to the laboratory. They were not required to "write it up." They did not understand all they saw but they have a new vision of the wonderful field in which they have begun to study.

Our electricity is furnished by the Central Illinois Public

Service Co. from its great Central plant at the mines near Harrisburg, Illinois, forty miles away. We visited the substation from which the power is distributed to our city. Only a few years ago the coal was hauled to us in heavy freight cars to run our local plant. Now the energy in the coal is transformed into electrical energy by means of monster dynamos and shipped to many towns in that marvelous new way, over high tension wires. The class prophesied that in a few years we sball not see the long trains of heavily loaded cars leaving this coal region. Great power plants will be erected at the mines and from these will radiate wires bearing silently tremendous loads of energy to farms, factories, and homes hundreds of miles away. This is the work of the physics engineer and the class sees in Charles P. Steinmetz one of the benefactors of the race. We saw lightning arresters with their horn gaps and the large transformers stepping the voltage down from 33,000 to 2,300. Because of the danger of such high voltages these were securely inclosed by a high heavy woven wire fence.

Inside the building we saw the engines, the dynamos, recording ammeters, volt meters and wattmeters. One of the dynamos is drum wound and the other two ring wound. We observed exciters, commutators, collecting rings, high velocities and beautiful motions. Sometimes when the mines are using large quantities of power the central plant can not furnish all that we need. The engineer showed us how he synchronized the two currents and then switched in the local plant on the line.

High tension wires, insulation, transformers, direct and alternating current and all the rest have a new and enlarged meaning for the class after such a visit. They have been accustomed to turn on the lights or the motor or the toaster in their homes and the results were a matter of course. Now they are factors in a wonderful series of physical phenomena. In the future they will admire the almost undisturbed service and decline to join in the general chorus of grumbling when on rare occasions the lights fail or the voltage is low.

I must not tire you with further detailed descriptions. We have visited the ice plant, the telephone central, the school heating plant. A house was being moved near by and we watched the operation of the capstan and the block and tackle. There are no notes required, little data collected, and the pupils do not have to "write them up." Frequent use of the observations in future class discussions show that practically all the boys and girls have had their eyes and ears wide open.

If there is a cornetist or violinist in the class, he makes special preparation for a discussion including demonstration of his instrument for the class. We listen to a real piano, a real reed organ, a real pipe organ. Next spring we shall visit a new garment factory to see how a modern factory is lighted. Boys have substituted a study of the electric system and the gas engine in their automobiles for two experiments. The girls have done the same with the refrigerator and electrical appliances in the home.

It would be easy to consume too much time with this kind of work and the visits must be well directed else they will degenerate into mere picnics. Certainly many teachers of physics have done far too little to connect up the thinking of their pupils with applications outside their laboratory. Especially do the girls need it. We men teachers use illustrations from our own experiences, not realizing that they are mere empty words to most of the girls for they have not had similar experiences. I have found the girls in these special studies quite as wide awake, as deeply interested, as earnest as the boys. While no written reports are required during the remainder of the year, we draw liberally upon our common fund of experience in our class discussions.

Let me repeat what I said in the beginning. The backbone of the course is in the lecture room and the laboratory. It does and ought to call for the very best efforts of the pupils. It should give considerable training in scientific method of thinking and doing. It should require laws, formulas, problems, experiments, written reports, examinations. The line of work which I have indicated does not detract from these essentials. It gives them a richer meaning; it vitalizes the work; it gives all our boys and girls a higher regard for science. When their school days are over they will continue to see physics in the things round them.

Then, too, there may be somewhere in your classes or in mine a boy capable of preparing now to continue the investigations of a Michelson or a girl to receive the mantle of Curie. No matter how well our laboratory may be equipped, no matter how well our course may be organized, if our teaching is cold and dead, if it lacks interest and inspiration, that boy or that girl may never discover the possibilities that lie out in the future. What a privilege to teach with such skill and inspiration as to develop every member of the class to the limit of his capacity and perchance cause some boy or girl to consecrate a talented life to the service of science!

THE REALIZATION OF THE MAIN OBJECTIVES OF SECONDARY EDUCATION THROUGH THE TEACHING OF PHYSICS.[1]

By John K. Skinner,

Senn High School, Chicago, Ill.

In Bulletin No. 26 on the Reorganization of Science, issued by the Department of the Interior, Bureau of Education, the objectives of secondary education are stated and explained. The use of each science in the accomplishment of these objectives is discussed at length. The Problem Project Method is elaborated, and recommended as practically the only way of teaching a science to really accomplish these aims. At a recent meeting of Chicago high school teachers of Physics and Chemistry, a former supporter of the Problem Project Method, a Physics teacher, used this statement: "In our large classes there ain't no such an animal." On the other hand, a paper written by Mr. Barger of Normal, Illinois, and read in the Physics section of the recent Illinois Conference, again recommends the Problem Project Method. The value of this method is in question among our Physics teachers.

The conclusion to the discussion of Physics in Bulletin No. 26, is worth our consideration. It is this: "The motto, 'Not how much, but how well,' should control the choice of our subject matter. Quality rather than quantity of knowledge should be sought; and ability to control materials, forces, and ideas should be the aim, rather than the mere acquisition of facts and laws."

What, in a course in Physics, should be taught well? What should every high school girl and boy be able to do after his course in Physics is completed? What should be included in a course in Physics to meet the aims of secondary education? This we have been trying to answer. Have we succeeded? In the light of Dr. Morrison's idea of Master, is our list of minimum essentials what we wish it to be? Are we willing to work on the improvement of this list to prevent Physics from losing its place in the curriculum?

Some of this is old. It needs to be repeated. When business is dull it pays to advertise. We must have the goods to advertise. We believe we have them, but we must know what they are. We must agree on some definite requirements to meet our aims. The agreement made, the advertising done, we must sell the goods. Maybe we believe all this is being done, but when fewer than half of the students in our large high schools are buy-

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[1]Read before the Physics Section of the C. A. S. & M. T. of the Soldan High School, St. Louis, Nov. 25, 1921.

ing, the market is dull for the goods we believe every student should have.

I haven't the solution of our problem, but I do believe that agreements must be reached as to minimum essentials first. Then we must advertise and sell. We should all have a part in the agreement and the advertising, as we all do have a part in the selling.

The committee on curriculum reconstruction, in their recent report to the Illinois Conference, showed a work of progress from their organization in 1918 to the present time. Their problem of construction of a curriculum to meet the needs of economic, political and social life, is a big one. Their aim to drop the traditional courses in the curriculum will probably not be accomplished in many cases, but they have awakened a determination on the part of many to keep the good in their courses, and to drop some of the material that they believe to be of little value. The Mathematics people have certainly been busy. We of the Physics section, I fear, cannot boast of so much.

We all agree with the reconstruction committee that our school work should result in happy and efficient workers, happy and efficient citizens of nation, state, and community, happy and efficient members of family, church, and local society. We may not agree on the choice of words used in the naming of the four major objectives to be used in achieving these results. We will admit, however, that these four objectives, namely: Health Wealth, Association, and Beauty; if kept clearly in mind by all educators, will contribute greatly toward the economic, political, and social life of our students.

Under the list of Health objectives outlined by the committee, we find one item—knowledge of proper heating and ventilation—to which we can lay claim. General Science teachers may claim that they take care of this. In the list of Wealth objectives are found only two: (1) Checking of meter readings; and (2) Knowledge that will enable one to perform certain activities connected with the home or place of business; as care of common tools, machinery, and electrical appliances. Others in the list that we may share in, are: Habit of keeping things in order; Skill in use of adequate vocabulary; Habit of being fair, square and honest; Habit of attention; Skill in cooperating with others; Skill in various self-expressions; Skill in taking part in an informal discussion without deviation, and without discourtesy to others. General Science may cliam all of these.

In the Association objectives, we find but one: Skill in caring for a motor car—and the others in which we may assist are: Habit of strict obedience to both spirit and letter of the law; appreciation of the time of others; appreciation of the cost of education; habit of doing one's share in the cooperative conservation of society's material wealth; and habit of making plans for the things one does.

In the list of Beauty objectives, we can claim only this portion of one: Knowledge . . . that will make possible the appreciation of the beauty of the forces and laws of the universe. It seems that our Physics teachers have contributed little to this list of nearly three hundred objectives named by teachers of the State of Illinois.

When we consider the fact that Physics ranks probably second only to Machine Shop courses in cost per pupil, and that many principals see little or no value in our course, it is time we were getting busy. There isn't one real Physics teacher that does not believe his subject to be full of the best material that can be taught to high school students, and yet this is not enough. The public must believe in our course. How can we get the public to believe in it? Not by putting into it everything we can find to crowd the course; but by selecting the best, and teaching it so well that the results of our work will advertise it for us. In selecting the best—our first great task—we should all agree to a list of units to be taught, and I am sure we can and will when we realize the necessity for doing this work.

In Bulletin No. 26 we are told that science study will be increased if high school science is planned as a whole, and if the separate courses are made to follow fundamental principles of sequence. It has been generally conceded that Physics should precede Chemistry, and yet in many of our classes we have a number who have had a Chemistry course in with those who have had no Chemistry. This classification we know to be poor and to interfere greatly with the success of the class. We should right this wrong in every school where such a condition exists.

After selecting the best in our course, we must arrange the material in such a way as to follow fundamental principles of sequence; and then, as far as possible, divide it into units to be mastered one by one. The system in our high schools requires monthly, quarterly, or half-semester reports. These units could be arranged to fit into any and all the various systems.

Some may say, let each one select his own list; and the one

who arranges his own will do better work by having made the arrangement for himself; but by this method of procedure, each one will be using his own hobby to the neglect of other essentials of the course. Then some have been discouraged because their contributions have been used in producing a text or manual from which another reaps a personal benefit. If we can carry on our work through this Association, then no one need fear the misuse of his contribution. Then, to enlist the services of everyone, would mean that no one would find the work so heavy that he would feel the need of financial remuneration, especially if the Association met all necessary expenses. I think our own Dr. Watson, Physics instructor at the University of Illinois, has set a good example for us to follow Many of you know of his wonderful application of sound reflection in correcting the acoustics in auditoriums; and that he has taken no little trouble to keep the use of his idea free to the public from patent fees.

It is the desire of a group of us that during the coming year there shall be worked out a set of units to meet the aims of secondary education; one that we will all agree to have mastered by every individual in our classes before he receives credit for the course. We wish to enlist the aid of every member of the Physics section. It will require a little time of everyone, but will place no great burden on any one if all help.

In doing this work, let us keep in mind that conclusion in Bulletin No. 26, "not how much, but how well; quality rather than quality," and then we will find mastery possible. How can we be sure of the mastery, may be the question of some. If we use the "teach, test, and teach again," method, we must be able to test as well as to teach. We must be able to know from the results of our test when mastery is reached. A little good work in the line of Standardized Physics Tests has been done. Some of these by Jones of Cleveland, Ohio, are very good. A standardized test may be produced to show the student definitely his success or failure as to mastery of each unit. Those who have succeeded may do outside work for excess credit. Those who have not, must get it before the new unit is begun.

The change in attitude on the part of the pupils towards their work is an interesting one—and I know of one teacher having a change of heart. Teacher and pupils take up the task with greater determination. Handling the next unit is a cooperative task. The aim of all is mastery by every student in the class before the first test is given on the unit.

LEARNING TO MULTIPLY FRACTIONS.

By Myrtie Collier,
Assistant Professor of Mathematics, University of California, Southern Branch.

Many teachers introduce the multiplication of fractions at the time the child is learning the multiplication tables. For example, after having learned that $3\times4 = 12$, the child is asked, "What is $\frac{1}{3}$ of 12?" He may give the correct answer, "four," but does he not think in terms of whole numbers, as $3\times? = 12$, or $3\overline{)12}$ with 4 above, or $12\div3 = 4$. Is not the child's concept of fractions so limited at this time as to make the multiplication of fractions of little significance? If his first concept of a fraction is one or more of the equal parts of *unity*, the above type of work must be after he has had much work in fractions.

The following experiment in the learning of multiplication of fractions was undertaken to answer three questions:

First: Does the child's mental processes relate to fractions or whole numbers when finding the fractional parts in connection with his work in learning the multiplication tables, as: 1/6 of 42, 1/7 of 35, etc.?

Second: In taking up formal work in the multiplication of fractions, does the child more easily grasp the repetition of a fraction a given number of times, as $4\times\frac{2}{3}$; or the taking of a fractional part of a group, as $\frac{2}{3}$ of 4?

Third: Does the child approach multiplication of fractions through addition of fractions, or by some other method?

A fifth grade class, which had been given the fractional parts in the learning of the multiplication tables, and which had spent two or more weeks on the addition of fractions was chosen for the experiment. A test in addition of fractions was given to obtain data which would give a basis for the division of the class into two groups of equal ability in numbering.

Group I began by taking the fractional part of a group, $\frac{2}{3}$ of 4.

Each child was supplied with a ruler, pencil, scratch paper, and two sheets of foolscap for cutting or folding. The class was instructed to keep $\frac{1}{3}$ of the two sheets of foolscap and return what they did not keep to the desk. They were then asked to make a statement of what they had done.

This type of work continued for four mornings, 95 minutes in all. Each morning the problem was changed so that any outside assistance would not enter into the results of the experiment.

Each child kept his results before him and from this data formulated his principle which he gave orally to the teacher in charge.

On the fifth morning the group was given a two minutes' test of twenty-five examples of the type upon which they had been working.

Group II began by repeating the fraction a given number of times, as $4 \times 2/3$.

As in the first case, each child was supplied with a ruler, paper, pencil, etc., and was given the following problem; It will take $2/3$ of a sheet of paper to make a booklet. How many sheets will it take to make 2 booklets?

This type of work continued through a part of the thirty-minutes period, until each member of the group had formulated his principle from the statements of his results.[1]

The following morning Group II was given a two-minutes test of twenty-five examples of the type presented the day before. (The test sheet was poorly typed, and caused delay.)

Group I was then given the type of problem which had been presented to group II, $4 \times 2/3$. A two-minutes test of twenty-five examples followed immediately after the deduction of the principle. Group II was given the type which group I had had presented first, with the same test following the deduction of the principle.

	Total time required for deduction	Aver. number problems cor.	Per cent accuracy
Group I	—4600 sec. average per pupil	21.2	98.3
Group II	—3041 sec. average per pupil	18.3	98

35 per cent of time saved by Group II.

The answers to the three questions as made by this experiment are as follows:

To question one, the child's mental processes relates to whole numbers and not fractions. For example, if asked what is $1/4$ of 24 when learning the multiplication tables, he thinks— $24 \div 4 = 6$, or there are 6 fours in 24.

To question two, in taking up formal work in the multiplication of fractions, time is saved by presenting *first* the repetition of a fraction a given number of times, $4 \times 2/3$; or the multiplication of a fraction by a whole number.

To question three, each child approached the multiplication of fractions through addition of fractions. For example, when

[1] The experiment was conducted by Helen Keller, Supervisor of Adjustment Work, University of California, Southern Branch.

Following is the result of the experiment.

Group I	Type ¼ of 2 Time required to discover rule	Test Time	Att.	Rt.
Pupil				
A	1560 sec.	120 sec.	22	22
B	4800 sec.	120 sec.	16	16
C	6600 sec.	85 sec.	25	25
D	5100 sec.	120 sec.	23	23
Total	18060 sec.	445 sec.	86	86
Average	4515 sec.	111.2 sec.	21.5	21.5

Group II Pupil	Type 4 × ⅔			
E	2100 sec.	120 sec.	17	17
F	1200 sec.	95 sec.	25	25
G	1500 sec.	120 sec.	12	11
H	1800 sec.	120 sec.	20	20
Total	6600 sec.	455 sec.	74	73
Average	1650 sec.	113.7 sec.	18.5	18.2

Group I Pupil	Type 4 × ⅔			
A	85 sec.	100 sec.	25	24
B	80 sec.	120 sec.	15	15
C	45 sec.	90 sec.	25	25
D	150 sec.	120 sec.	22	20
Total	340 sec.	430 sec.	77	84
Average	85 sec.	107.5 sec.	21.7	21

Group II Pupil	Type ¼ of 2			
E	2400 sec.	92 sec.	25	25
F	1200 sec.	95 sec.	25	25
G	1500 sec.	120 sec.	17	17
H	465 sec.	120 sec.	9	7
Total	5565 sec.	427 sec.	76	74
Average	1391.2 sec.	106.7 sec.	19	18.5

finding ⅓ of 2 sheets of paper, each child said ⅓ of the first sheet of paper, and ⅓ of the second sheet of paper, then ex-

pressed it thus: $\frac{1}{3}+\frac{1}{3} = \frac{2}{3}$. When finding $\frac{2}{3}$ of 4, each child thought $\frac{2}{3}$ $\frac{2}{3}$ $\frac{2}{3}$ $\frac{2}{3}$ = 8/3. (Few of them wrote the sign.)

Following is a type form of procedure in presenting multiplication of fractions:

First. Have some problem which involves the repetition of a fraction a given number of times, as $5 \times \frac{2}{3} = ?$.

Second. Ask the child to answer the following question by means of measuring, paper tearing, etc., and write the results as:

	Teacher	Pupil	
(a)	$2\times\frac{1}{2} = ?$	$2\times\frac{1}{2} = 1$	$(\frac{1}{2}+\frac{1}{2} = 1$
(b)	$2\times\frac{3}{4} = ?$	$2\times\frac{3}{4} = 1\frac{1}{2}$	$(\frac{3}{4}+\frac{3}{4} = 6/4 = 1\frac{1}{2}$
(c)	$3\times\frac{1}{4} = ?$	$3\times\frac{1}{4} = \frac{3}{4}$	$(\frac{1}{4}+\frac{1}{4}+\frac{1}{4} = \frac{3}{4}$
(d)	$3\times\frac{3}{4} = ?$	$\frac{3}{4}+\frac{3}{4}+\frac{3}{4} = 9/4 = 2\frac{1}{4}$	
(e)	$7\times\frac{2}{3} = ?$	$\frac{2}{3}+\frac{2}{3}+\frac{2}{3}+\frac{2}{3}+\frac{2}{3}+\frac{2}{3}+\frac{2}{3} = 14/3 = 4\frac{2}{3}$	

Ask the child if he cannot find a quicker way than to add all the fractions; or what combinations he made with the digits, and he will tell you that he multiplied the numerator by the whole number and wrote the answer over the denominator.

Third. Tell him to use his new principle to find $9\times\frac{3}{4}$.

He thinks (1) $9\times3 = 27$

(2) 27/4

(3) $9\times\frac{3}{4} = 27/4$.

Check his results by adding, thus: $\frac{3}{4}+\frac{3}{4}+\frac{3}{4}+\frac{3}{4}+\frac{3}{4}+\frac{3}{4}+\frac{3}{4}+\frac{3}{4}+\frac{3}{4} = 27/4$.

Then give drill immediately to fix the process.

$7\times\frac{2}{3} = ?$	$9\ \frac{2}{3}$	18 3/8	The reduction of the answer is not
$8\times\frac{2}{3} = ?$	$\times 6$	$\times 7$	new, and should therefore follow
$13\times\frac{3}{4} = ?$	——	——	immediately, as $9\times\frac{3}{4} = 27/4$
			$= 6\frac{3}{4}$

From this go to the form $\frac{1}{2}$ of 3, or where the child is to find the fractional part of a group. If the child does not know at once that it will be the same as the first process, namely, that the numerator and the whole number are multiplied together and the product written over the denominator, let him have material and a few minutes' time to figure it out. It has been the writer's experience that again the child thinks the fraction added to itself the given number of times, as:

$$\frac{1}{2} \text{ of } 3 = \frac{1}{2}+\frac{1}{2}+\frac{1}{2} \text{ etc.}$$

In other words, when working with the concrete the child will take $\frac{1}{2}$ of each whole and then add his three halves, etc.

Multiplying a fraction by a fraction is a much more complicated process, and after the two simpler processes have been mastered, the following is a suggested procedure for the work.

Teacher: "What is $\frac{1}{2}$ of $\frac{1}{2}$?"

Pupil takes ½ of a half of something and answers "¼," writing ½ of ½ = ¼.

Repeat this type of question and answer with several combinations, as:

½ of ¾ = 3/8
⅔ of ⅔ = 4/9
¼ of ⅓ = 1/12.

In this way the child will discover that the numerators are multiplied together for a new numerator and the denominators for a new denominator. All reductions of answers to simpler forms, as ¼ of ⅔ = 2/12 = 1/6 and all short cuts as ¼ of ⅔ = 1/6. Thus, dividing mentally before multiplying should follow, and *should be discovered by the child,* guided by the skilful questioning of the teacher.

After the principle of multiplication of fractions has been discovered by the pupil, much practical work and drill should follow immediately.

Following are some suggestions for practical work.

1. Taking ½ of a recipe. (As: Efficiency Arith., Intermediate, P. 76.)

CHOCOLATE NUT FUDGE.
1½ cups granulated sugar
½ cup light brown sugar
½ cup grated chocolate
¾ cup milk
butter, size of walnut
½ cup chopped nut meats
vanilla

For drill, follow with other recipes and take ¾, or 1½, or 2 times the recipes. Also give as abstract drill all the fractions involved in the problems, and other similar fractions, as ½ of ½, ½ of ¾, 2×¾, 2×1½, 2×2¼, ½ of 2¼, etc.

2. Playing store and making bills, as:

SMITH BROS. GROCERY.

4½ lb. sugar at 16c	$ .72
¾ lb. butter at 54c	.41
¾ lb. bacon at 65c	.49
2½ doz. eggs at 58c	1.45
Total	$3.07

Formal drill to follow:

18×4½, ¾×56, 98×2½

Formal drill to follow:

43×4¼ 67×23/4 37×2¾

JONES BROS. DEPARTMENT STORE.

4½ yd. gingham at 60c	$2.70
¾ yd. lace at 18c	.15
1¼ yd. ribbon at 38c	.48
Total	$3.33

The multiplication of a mixed number by a mixed number does not involve anything new.

The term "cancelling" should not be used in the reduction of fractions, the multiplication of fractions, or the division of fractions. It is wholly unnecessary and often confusing to the child. Use the expression "Divide both numerator and denominator by the same number."

A splendid form of checking the result in multiplication of fractions is to begin with zero and count by the fraction.

Example	Check
$7 \times \frac{3}{4} = 21/4 = 5\frac{1}{4}$	$0, \frac{3}{4}, 6/4, 9/4, 12/4, 15/4, 18/4, 21/4, 5\frac{1}{4}$
	or $\frac{3}{4}, 1\,2/4, 2\frac{1}{4}, 3, 3\frac{3}{4}, 4\,2/4, 5\frac{1}{4}$.

ILLINOIS STATE ACADEMY OF SCIENCE.
APRIL 27-29, 1922.

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THE FREQUENCY OF CERTAIN PROBLEM SOLVING SITUATIONS IN THE HIGH SCHOOL CURRICULUM AND A SUGGESTED GENERAL METHOD OF SOLUTION.[1]

By Frank C. Touton,

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Problem.

Teachers generally agree that many secondary school pupils experience much difficulty and little success in their attempts to solve independently those verbally stated problems which require in their solutions both reasoning and operations with the fundamental processes. That such problems do occur with great frequency in the mathematical and natural science subjects of the high school curriculum is a matter of common knowledge.

It has been called to my attention that the mathematical abilities of an entire family are sometimes exercised and even taxed in an attempt to do for the pupil that which the teacher had evidently intended the pupil to do for himself. In problem solving as in the formal work of mathematics, *the two real tests of good teaching are successful achievement and evidence of increasingly independent activity on the part of pupils.*

Purpose.

It is the purpose of the writer at this time:

1st. To make a brief report on the place taken by problem solving situations of the quantitative sort in the secondary school curriculum.

2nd. To consider the need for a special technique in training pupils to solve those problems which involve both reasoning and operations with fundamentals.

3d. To suggest a method of solution, the several steps of which correspond to a psychological analysis of the thought processes utilized in solving problems of a quantitative type.

Textbook Analysis.

Having accepted the thesis that "It is the duty of the school to teach the pupil to do better those desirable activities which he is to do anyway," it occurred to me that it would be both interesting and perhaps profitable to know the extent to which pupils encounter problem solving situations of the type here considered while engaged in the study of certain subjects in the

[1]Paper read before the Mathematics Section of the California State Teachers Association at San Francisco, October, 1921.

secondary school curriculum. In the securing of data on this point I have had the assistance of seniors and graduate students enrolled in my classes in Education at the University of California.

The study made, in so far as it is here reported, shows for each text examined (a) the number of problems completely solved for the guidance of the pupil (b) the number of hints or partial solutions given with the evident purpose of teaching pupils to solve, with a minimum of help, such problems as require in their solutions both reasoning and computation of an arithmetic or algebraic sort and (c) the number of problems to be solved by the pupil.

The following table shows for each text examined, (a) the number of problems solved in full in the text, (b) then number solved in part in the text, and (c) the number to be solved by the pupil. These items, only, are selected out from those listed in the more extended analysis made by those students who examined the several texts.

Subject. First Year Algebra.

Text.	A	B	C	D	E	F	G	H	I	J	K
(a) Text problems solved in full	33	30	105	13	17	29	15	40	17	32	10
(b) Text problems solved in part	17	33	60	17	16	10	28	17	14	0	38
(c) Text problems to be solved by pupil	540	550	439	359	482	262	310	354	441	225	520

Subject. Second Year Algebra.

Text.	A	B	C	D
(a) Text problems solved in full	12	28	10	17
(b) Text problems solved in part	22	8	30	20
(c) Text problems to be solved by pupils	340	220	238	200

Subject. Plane Geometry.

Text.	A	B	C	D	E	F
(a) Text problems solved in full	4	5	3	15	7	6
(b) Text problems solved in part	12	6	11	4	0	20
(c) Text problems to be solved by pupils	247	248	308	210	520	366

Subject. Solid Geometry.

Text.	A	B	C	D
(a) Text problems solved in full	4	5	10	12
(b) Text problems solved in part	0	0	0	12
(c) Text problems to be solved by pupils	400	84	370	276

Subject. Junior High School Mathematics.

Text.	A	B	C	D	E	F
(a) Text problems solved in full	40	66	30	55	60	45
(b) Text problems solved in part	35	82	5	11	15	16
(c) Text problems to be solved by pupils	800	840	245	237	522	452

Subject. Business Arithmetic.

Text.	A	B	C	D	E	F	G
(a) Text problems solved in full	46	110	159	132	130	48	175
(b) Text problems solved in part	5	17	2	35	15	50	20
(c) Text problems to be solved by pupils	994	1100	651	945	520	1150	1850

Subject. General Mathematics.

Text.	A	B	C	D	E
(a) Text problems solved in full	31	63	28	46	65
(b) Text problems solved in part	82	54	2	19	14
(c) Text problems to be solved by pupils	673	960	470	584	78

Subject. Physics.

Text.	A	B	C	D	E	F
(a) Text problems solved in full	52	18	25	20	26	20
(b) Text problems solved in part	4	7	0	10	0	37
(c) Text problems to be solved by pupils	470	360	150	190	95	209

Subject. Chemistry.

Text.	A	B	C	D	E	F	G	H	I
(a) Text problems solved in full	16	12	55	14	14	5	15	8	4
(b) Text problems solved in part	4	3	37	0	0	10	20	0	2
(c) Text problems to be solved by pupils	121	85	152	158	72	30	82	74	43

Subject. General Science.

Text.	A	B	C
(a) Text problems solved in full	14	14	25
(b) Text problems solved in part	4	0	10
(c) Text problems to be solved by pupils	14	10	95

It appears from the above tabulation, that in certain of the subjects which make up the high school curriculum in mathematics and science, pupils are required to solve many problems and that they are given by the texts unequal amounts of assistance in their efforts to master the technique of solving those problems. The time thus spent in other fields than mathematics and science is not great, as is shown in another study not here reported, but will in the opinion of the writer increase in the next decade; for more and more men of today are inclined to be dissatisfied with general statements. There seems to be a growing desire to know *not only what, but how much.*

The Need for Special Technique in Problem Solving

That the possession of ability to succeed in operations involving one or more of the fundamentals of arithmetic (addition, subtraction, multiplication and division) carries with it a reasonably high degree of success in performing any or all of the other fundamentals is seen from the following results obtained by Dr. Stone in his tests in fundamentals which were given to a sampling of 500 pupils. His results are here quoted:

The correlation also.

between addition	and subtraction	was +0.50;
between addition	and multiplication	was +0.65;
between addition	and division	was +0.56;
between subtraction	and multiplication	was +0.89;
between subtraction	and division	was +0.98;
between multiplication	and division	was +0.95.

The above correlations show close relationships between achievement in division and in multiplication which indicates that the possession of ability in division carries with it almost the same level of ability in subtraction and in multiplication. The correlations here quoted simply bear out facts perfectly well known to teachers of arithmetic.

The results obtained by Dr. Stone through relating the achievements of these 500 pupils in each and all of the fundamentals to the achievements of these pupils in reasoning with arithmetical data do not show as high correlations as were obtained in relat-

ing the achievements of pupils in the several fundamental operations.

The relationships which were found by Dr. Stone when expressed as coefficients of correlation as here quoted:

Reasoning with the fundamentals combined	+0.32;
Reasoning with addition	+0.28;
Reasoning with subtraction	+0.36;
Reasoning with multiplication	+0.34;
Reasoning with division	+0.36.

In a study made in the Speyer Junior High School in New York City in 1917, the writer found a correlation of +0.34 between the scores of 125 boys in the Stone Reasoning test and their scores in the Woody Division test.

The low degrees of correlation between fundamentals and reasoning as here quoted indicate that abilities in the fundamentals of arithmetic are different abilities from those utilized in reasoning with arithmetical data. If a high level of achievement in this type of reasoning is desired, more effective teaching methods can be utilized than to provide training in the fundamentals of arithmetic alone.*

Now if ability in dealing with arithmetical situations of the problem sort can be trained, the best practicable method of procedure should be sought. The consensus of opinion of teachers, parents, and business men is that most secondary school pupils have much difficulty and little success in solving those verbally stated problems in which numerical results are required. A part of this failure is no doubt due to errors made in operations involving the fundamental processes, yet the results quoted above show that the attainment of a high degree of accuracy in fundamentals will not in and of itself guarantee success in meeting problem solving situations involving both reasoning and computation.

From two points of view we have seen the need for teaching

*Perfect correlation (or perfect correspondence) is represented by +1.00 indicating a 1:1 relationship between the traits in question; correlation (or chance relationship) by 0; and a strictly opposite relationship by −1.00. A correlation of such as +0.30 indicates a positive but low degree of relationship while +0.80 indicates a high degree of relationship between the measures and therefore between the traits measured.

technique, if pupils are to be trained to meet successfully problem solving situations:

1st. The frequent occurrence of problems in the high school curriculum; and

2d. The fact that a specialized type of teaching is required.

PROBLEM SOLVING ANALYZED.

The concluding portion of this paper will deal with a psychological analysis of the thought processes utilized in the *solutions which involve both reasoning and computation* and will suggest a technique of solution based on this analysis. Several typical solutions will be presented showing how such an analysis may be embodied in a general method of solution for such problems. The outline here given for analyzing verbal problems results from a critical analysis of my own thinking and experience in teaching pupils to solve problems and from the observation of the work of many teachers and pupils in such situations.

As I recall the matter I was led to make my first analysis of the thought processes involved in problem solving in an attempt to suggest to pupils a definite and helpful method of procedure in their solution of problems in elementary algebra. For some time now the analysis of the thinking done in problem solving which involves reasoning and computation of an algebraic sort has appeared to me to consist in the main in the following mental processes. Each of the six processes here given can, of course, be further broken up into detailed methods of procedure. Further analysis is probably necessary and should doubtless be made.

In its present form, the analysis suggested has been used as a basis of discussion with several hundred teachers of mathematics and is here offered for that specific purpose. The analysis follows:

Step I. Identification of the several elements of the given data. Here certain elements will be recognized as known facts and others will be identified as new or unknown.

Step II. Seeking out and expressing as an equality the quantitative relationship or central thought of the problem.

Step III. Representation of the several unknowns in terms of number symbols.

Step IV. Substitution of known elements and those represented by the number symbols of Step III into the fundamental equality of Step II.

Step V. Solution of the equation formed in Step IV.

Step VI. Checking the results obtained from the solution of Step V.

In somewhat greater detail the above analysis is expanded and expressed in terms of steps necessary to the solution of a problem which involves a quantitative relationship as follows:

Step I. *Identification of elements.* Reading the problem to identify the several given facts and the required fact or facts.

Step II. *Expressing the quantitative relationship.* Determining the quantitative relationship (or equality) existing between the several elements of the problem, both known and unknown and expressing this equality briefly in words (or abbreviations) using where possible the sign of equality (=), and the symbols of operation +, −, ×, ÷, and the fraction line.

Step III. *Representation using symbols.* Representation of each unknown number in the problem in terms of a letter or a letter and a number.

Step IV. *Substitution.* Substituting the numerical values given in the statement of the problem and noted in Step I, for such known quantities as appear in the expressed equality and substituting the symbols obtained in Step III for the unknown quantities of the expressed equality.

Step V. *Solution of the equation.* Solving the equation thus obtained to get the value of the unknown number which was represented by the letter involved, and where necessary substituting this value in the other number symbols of Step III to find the values of the other quantities identified as unknown elements in the statement of the problem.

Step VI. *Check.* Checking the work through the substitution of the numerical result obtained for the unknown quantities along with the given values for the known quantities as stated in the text of the problem, or in the equality of Step II, thereby determining whether or not the conditions of the problems are satisfied by the values found for the unknown numbers.

The application of the six steps given above to the solution of such problems as have quantitative relationships which can be expressed by a simple equation will appear in the solution of the following problems:

Example i.

The sum of two numbers is 72, and the greater is three times the less. Find both numbers.

(Identification) *Solution.*

Step I. Two unknown numbers are to be found. Their sum is 72. One number is three times the other.

Step II. (Expressing the quantitative relationship)

Greater + less = 72.

Step III. (Representation, using symbols)

Let l = the less number,

then $3l$ = the greater number.

Step IV. (Substitution of symbols)

$$3l+l = 72.$$

Step V. (Solving the equation)

$$4l = 72.$$

$l = 18$, the less number,

and $3l = 54$, the greater number.

Step VI. (Check) $54+18 = 72,\ 72 = 72.$

$$54 = 3\times 18.$$

EXAMPLE II.

A stick 120 inches long is to be cut into two pieces, one of which is to be 14 inches more than three times the length of the other. How long is each piece?

Solution.

Step I. (Identification) The stick is 120 in. long, the length of the pieces are to be determined, one is to be 14 in. more than three times the other.

Step II. (Quantitative relationship)

Greater length + less length = 120 in.

Step III. (Representation, using symbols)

Let l = no. of inches in shorter piece.

then $3l+14$ = no. of inches in longer piece.

Step IV. (Substitution of symbols)

then $3l+14+l = 120$

Step V. (Solving the equation)

$$4l = 106.$$

$l = 26.5$ no. in. in shorter piece,

and $3l+14 = 93.5$ no. in. in longer piece.

Step VI. (Check)

$$93.5+26.5 = 120, \text{ or } 120 = 120.$$

$$93.5-26.5\times 3 = 14, \text{ or } 14 = 14.$$

EXAMPLE III.

The value of 30 coins, consisting of nickels and dimes, is $2.60. Find the number of each.

Solution.

Step I. Thirty coins are used, their value is $2.60. The number of nickels and the number of dimes is to be found.

Step II. Value of nickels + value of dimes = total value.

Step III.

$$
\begin{aligned}
\text{Let } n &= \text{no. of the nickels;}\\
\text{then } 5n &= \text{value of the nickels in cents,}\\
\text{and } (30-n) &= \text{no. of dimes,}\\
\text{and } 10(30-n) &= \text{value of dimes in cents.}
\end{aligned}
$$

Step IV. $5n+10(30-n) = 260.$

Step V.

$$
\begin{aligned}
5n+300-10n &= 260.\\
-5n &= -40.\\
n &= 8, \text{ number of nickels,}\\
30-n &= 22, \text{ number of dimes.}
\end{aligned}
$$

Step VI.

$$
\begin{aligned}
8\times5+10(22) &= 260, \text{ or } 260 = 260.\\
22+8 &= 30, \text{ or } 30 = 30.
\end{aligned}
$$

EXAMPLE IV.

A part of $4,560 is invested at 4% and the remainder at 6%. The total yearly income is $202.40. Find the amounts invested at each rate.

Solution.

Step I. Two parts of $4,560 are to be found. One part is invested at 4%, and the other at 6%. The total income yearly is $202.40.

Step II. 1st investment × 4% + second investment × 6% = yearly income.

Step III.

$$
\begin{aligned}
\text{Let } f &= \text{no. of dollars invested at } 4\%.\\
\text{then } 4560-f &= \text{no. of dollars invested at } 6\%.
\end{aligned}
$$

Step IV. $.04f+.06\,(4560-f) = 202.40.$

Step V.

$$
\begin{aligned}
4f+6(4560-f) &= 20240.\\
-2f &= -7120.\\
f &= 3560, \text{ no. of dollars at } 4\%.\\
4560-f &= 1000, \text{ no. of dollars at } 6\%.
\end{aligned}
$$

Step VI.

$$
\begin{aligned}
\$3,560\times4\%+\$1,000\times6\% &= \$202.40,\\
\$142.40+\$60.00 &= \$202.40,\\
\$202.40 &= \$202.40.\\
\$3,560+\$1,000 &= \$4,560.\\
\$4,560 &= \$4,560.
\end{aligned}
$$

EXAMPLE V.

The altitude of a triangle is twice the base and the area is 36 square feet. Find the base and the altitude.

Solution.

Step I. The altitude is twice base, the area 36 sq. ft., and the base and altitude are to be found.

Step II. ½ altitude × base = area of triangle.

Step III. Let b = no. of feet in base;
then $2b$ = no. of feet in altitude.

Step IV. $\frac{1}{2}\times 2b\times b = 36.$

Step V. $b^2 = 36.$

$b = 6$, no. of feet in base (-6 is rejected),

and $2b = 12$, no. of feet in altitude.

Step VI. $\frac{1}{2}\times 12\times 6 = 36$, or $36 = 36$.

$6\times 2 = 12$, or $12 = 12$.

EXAMPLE VI.

The sides of a triangle are 2′, 3′, and 4′ respectively. Find the segments of the 4 foot side made by the bisector of the angle opposite.

Solution.

Step I. The given triangle has sides, 2′, 3′, and 4′, respectively. The 4-foot side is cut into two parts, by the bisector of the angle between the 2- and 3-foot sides. Each segment of the 4-foot side must be found.

Step II.

$$\frac{2'}{3'} = \frac{\text{segment of 4-foot side adjacent to 2-foot side}}{\text{segment of 4-foot side adjacent to 3-foot side}}.$$

Step III.

Let l = length, in feet, of segment of 4-foot side adjacent to the 2-foot side.

Then $4-l$ = length, in feet, of other segment.

Step IV.

$$\frac{2}{3} = \frac{l}{4-l}$$

Step V.

$$8-2l = 3l.$$

$$\text{Whence } l = \frac{8}{5}, \text{ or } 1.6'.$$

$$\text{and } 4-l = 4'-1.6' = 2.4'.$$

Step VI.

$$\frac{2'}{3'} = \frac{1.6'}{2.4'}, \text{ or } 4.8' = 4.8'.$$

$$2.4'+1.6' = 4', \text{ or } 4' = 4'.$$

Example VII.

In attempting to move a rock by means of a 6-foot bar used as a lever, a man who weighs 160 lb. finds that he can just balance the rock at one end of the bar by placing the fulcrum 15″ from the rock and then bearing down with his whole weight at the other end of the bar. Find the weight of the rock.

Solution.

Step I. The fulcrum divides the bar into segments 1.25′ and 4.75′. The man's weight of 160 lb. is applied at the extreme end of the 4.75′ segment; the rock is located at the end of the short segment. The weight of the rock is to be found.

Step II. Wt. of rock × distance from fulcrum = wt. of man × his distance from the fulcrum.

Step III. Let r = weight of rock, in lb.

Step IV. $r \times 1.25 = 160 \times 4.75$.

Step V. $r = 608$ lb.

Step VI. $608 \times 1.25 = 160 \times 4.75$, or $760 = 760$.

Example VIII.

How many grams of carbon dioxide (CO_2 has molecular weight of 44) could be obtained by heating 10 grams of baking powder ($NaHCO_3$ has molecular weight of 84) if it decomposed according to the equation, $2\,NaHCO_3 = Na_2CO_3 + CO_2 + H_2O$?

Solution.

Step I.

2 molecules of $NaHCO_3$ decompose giving one molecule of CO_2.

2 molecules $NaHCO_3 = 2 \times 84 = 168$ grams.

1 molecule $CO_2 = 1 \times 44 = 44$ grams.

10 grams $NaHCO_3$ decompose giving an unknown weight of CO_2.

Step II.

2 molecules $NaHCO_3$/1 molecule CO_2 = 10 grams of $NaHCO_3$/Weight of CO_2 from 10 grams $NaHCO_3$.

Step III. Let w = weight of the CO_2 in grams.

Step IV. $168/44 = 10/w$.

Step V. $w = 44 \times 10/168 = 2.619$ grams.

Step VI. $168/44 = 10/2.62$, or $3.81 = 3.81$.

Suggested Procedure in Lesson Assignment.

After having worked out the solution of a limited number of verbal problems the pupil will find it unnecessary to write out

the statement of Step I, that is the identification of the several elements of the problem. This step can be taken mentally but should never be slighted. The other steps should be written out in approximately as much detail as appears in the examples given above.

In assigning the first lessons in the solution of verbal problems, the teacher may well work out with the class certain typical problems using as much detail as is here illustrated. Later it will be found necessary to go no farther than Step III, and still later no farther than Step II. The guidance of the teacher is needed through Steps I and II in many of the problems which are required of the entire class. The optional work given out as a challenge to the superior members of the class group, should of course receive a minimum amount of specific attention on the part of the teacher during lesson assignment period.

SUGGESTED FORM FOR CERTAIN ARITHMETIC SOLUTIONS.

The analysis of the thought processes involved in dealing with problem situations of the arithmetic type appears to differ in one essential only from that given above for algebraic, geometric, and science problem situations. The difference is this: The long standing custom (one I think certain to break down) demands that letters having unknown values, (particularly the letter x) shall not appear in the solution of an arithmetical problem. Even if this custom is to be respected and followed, it would be needful for us to omit Step III only, of the analysis problem. In all other important respects the analysis of the thought processes is identical with that found in solutions of the so-called algebraic type.

The identity of the processes involved is seen in the following analysis and solutions:

Step I. Identification of elements. Reading the problem to identify the several given facts and the required fact or facts.

Step II. Expressing quantitative relationship. Determining the quantitative relationship (or equality) existing between the several elements of the problem both known and unknown expressing this equality briefly in words or abbreviations, using where possible the sign of equality (=) and the symbol of operation +, −, ×, ÷ and the fraction.

Step III. Substitution. Substituting the numerical values given in the statement of the problem for the known quantities of Step II.

Step IV. Solution of the equation. Simplifying the equality thus obtained, performing such additional operations as are necessary to express numerically the required fact or facts.

Step V. Check. Checking work by the substitution of the numerical results for the previously unknown facts along with the given values for the known facts as stated in conditions of the problems, thereby determining whether or not the conditions of the problem are completely satisfied.

EXAMPLE I.

In selling an article at \$517.50 a merchant gained 15% of the cost. Find the cost.

Solution.

Step I. (Identification of elements) The selling price is \$517.50; the cost is not known and is required; 15% was gained on the cost.

Step II. (Quantitative relationship) The quantitative relationship or equality here is:

Cost + gain = selling price.

Step III. (Substitution) Substituting known numerical values from Step I in Step II above.

Step IV. Solving the equation)

$$\begin{aligned} \text{Cost}+15\%\ \text{Cost} &= \$517.50. \\ 115\%\ \text{Cost} &= \$517.50. \\ 1.15\ \text{Cost} &= \$517.50. \\ \text{Cost} &= \$517.50 \div 1.15 = \$450.00. \end{aligned}$$

Step V. (Check)

$$\begin{aligned} \$450.00+15\%\ (\$450.00) &= \$517.50. \\ \$450.00+\$67.50 &= \$517.50. \\ \$517.50 &= \$517.50. \end{aligned}$$

EXAMPLE II.

A commission merchant received a consignment of 50 crates of strawberries. He sold 10 crates at \$2.25, 20 crates at \$2.35, 2 crates were spoiled and thrown away, and the remainder were sold at \$2.10. Find the net proceeds after deducting 5% for commission and \$6.25 for charges.

Solution.

Step I. 50 crates were received; the sales were 10, 20, and 18 crates at \$2.25, \$2.35, and \$2.10 respectively. 5% is to be deducted for commission and \$6.25 for charges. The amount of the net proceeds is required.

Step II.

Proceeds = (1st sale + 2nd sale + 3rd sale) × 95/100 − charges.

Step III.

Proceeds = ($2.25 × 10 + $2.35 × 20 + $2.10 × 18) × 95/100 − charges.

Step IV.

Proceeds = ($22.50 + $47.00 + $37.80) × 0.95 − $6.25.
= ($107.30) × 0.95 − $6.25 = $95.68.

Step V.

($2.25 × 10 + $2.35 × 20 + $2.10 × 18) − 5% (sales) − $6.25 = $95.68.

$107.30 − $11.62 = $95.68.
$95.68 = $95.68.

CONCLUSION.

In the foregoing discussion, the following items have been considered:

(1) An examination of the content of certain textbooks brings out the fact that problem solving situations involving both reasoning and fundamental operations are frequently encountered by pupils, as they pursue the subjects which constitute the secondary school curriculum.

(2) It was suggested that quantitative relationships may come to occupy a position of increasing prominence in the experience of the secondary school pupil.

(3) It was pointed out that the abilities utilized in working out quantitative relationships are not identical with abilities utilized in the fundamental operations in arithmetic.

(4) A technique based on a psychological analysis of the thought processes involved, is suggested for the use of pupils as they deal with those problems solving situations which involve in their solutions both reasoning and the fundamental operations of arithmetic and algebra.

A NEW HONOR FOR JOHN MERLE COULTER OF THE UNIVERSITY OF CHICAGO.

Professor John Merle Coulter, Head of the Department of Botany at the University of Chicago and editor of the *Botanical Gazette*, has been elected a corresponding member of the Czecho-Slovakian Botanical Society "in recognition of the inestimable services he has rendered to, botanical science in the course of his studies." Professor Coulter, who has been president of the American Association for the Advancement of Science, the Botanical Society of America, and the Chicago Academy of Sciences, is the author of numerous volumes in his own field of research among them *Fundamentals of Plant Breeding*, *Evolution of Sex in Plants*, and *Plant Genetics*.

HOW MANY HOURS CONSTITUTE A DAY'S WORK IN A PHYSICS DEPARTMENT—DATA UPON THIS AND OTHER TOPICS OF INTEREST TO TEACHERS OF PHYSICS.

By Philo F. Hammond,

University of Wyoming, Laramie.

There is a regulation of the faculty of the University of Wyoming fixing the maximum number of credit-hours for an instructor at eighteen per week and the minimum at twelve per week. The number of credit-hours for an instructor in the department of physics for the past year was equivalent to eighteen hours per week—just within the limit of the maximum fixed by this regulation. This, however, gave him twenty-eight teaching-hours which is, so far as the writer knows, more than is required by any other department of physics on the North American Continent.[1] All courses given were required and there was, therefore, no chance to cut down hours by reducing the number of courses. To instructors in most institutions the maximum number of credit hours set by this regulation will probably be considered high for courses where the number of credit-hours coincides with the number of teaching-hours; but in a department like physics where formal lectures are given—and especially with no assistant to set up apparatus—and where a large part of the instruction is in the laboratory it will be obvious to instructors acquainted with the demands of such work upon time and energy that such a program is quite impossible if the department expects to even approach the efficiency of the average institution. In order to add authority to his opinion upon this point and to bring it and other conditions where the efficiency of the department should be increased to the attention of the administration of the institution the writer sent out a questionnaire to institutions west of the Mississippi River, but there was such an interesting response and there were so many requests for resumes it was thought best to include institutions east of the Mississippi River as well.

A careful study of the answers to the questions of these questionnaires corroborates the views of the writer gained by his experience in other institutions and it shows that if an attempt is made to make a proper adjustment of working hours taking into consideration efficiency and quality of work together with cost of operation, any regulation based upon credit-hours is

[1]Physics teachers will better understand the situation when they know that for many years the physics lecture table has had neither sink and water nor electrical connections. These conditions are being remedied as fast as it is possible.

entirely futile. And while it would be a "better plan to limit the number of courses and work done in the department so that the instructors will have a fair amount of routine work to do and time for their own scholarly work" without regard to the number of credit-hours or teaching-hours, it seems necessary in some cases to have some criterion by which those in authority may know when an instructor has reached the number of hours work above which his work must become inefficient and poorly done, and the judgment of men in the departments of physics from many institutions ought to be worth more than the judgment of the head of any one department and may be accepted without prejudice.

Eighty-one questionnaires were sent out, from which fifty-two replies were received and answers returned from fifty. Perhaps some who did not reply felt very much as the writer of the following quotation: "I am not answering this questionnaire because frankly I do not approve of such methods of getting help for a department. * * * The determination of work of an instructor upon the basis of cost per student is a thoroughly vicious one and in the end tends to lower the best work in the department." However, the writer is inclined to believe that the arduous life of physicists mentioned in the quotation following, from a Canadian institution, was the cause of the failure to fill out the questionnaire in most cases: "Physicists are busy all day, nine to six, and have evening work, too. It is quite different from mathematics and classics where, men can go home, or else when not lecturing may or may not be students. They (physicists) also wish to enhance their reputation and extend knowledge by research work—a very arduous life, but a pleasant one." At any rate, to the writer at least, the number and character of the responses are most remarkable. While such a questionnaire might be filled out in fifteen or twenty minutes for a small institution, it was no small task for the larger ones, and in some cases for these some of the answers can be only approximations at the best. The data collected are so extensive and interesting it was thought best to let others have the benefit of it so far as possible. One misses a great deal, however, without the original reports, but space does not permit the publication of these.

The data here were compiled and reflect conditions for the fall of 1920. The enrollment for the larger institutions in the United States was taken from data published in *School and*

TABLE I.

College or University	Total Enrollment.	Number of Students taking Physics.	Percentage of Total Student Body taking Physics.	Average Number of Credit-hours per Instructor per Week.	Average Number of Teaching-hours per Instructor per Week.	Amount of Non-Teaching Help in Hours per Week, in the Physics Department.	To what Extent are Instructors in Department Overloaded.	No. hours laboratory teaching equivalent to one non-laboratory hour teaching.	Does your Department Conform to above Answer.	Length of Laboratory Periods in Hours.	Are Laboratory Reports Corrected after each Period? If not, How often are they Corrected?	Budget per Student Credit-hour.
Amherst College	503	40	8%	4	10	24	Not	2	Yes	2	Weekly	
Carnegie Institute of Technology	2,320				16	48	Not	1	Yes	2	Yes	
Clark University	278	40	14.3		11.3	4	45%		No	3	Weekly	$ 5.05
Case School of Applied Science	743	210	28.2		19	34		2		3	Yes	
Colorado College	680	60	8.8	12.5	16	*6 S. A.	Not	2	No	3	Weekly	
Harvard University	5,483	400	7.3	8		240	Not			3	Weekly	
Iowa State College	6,167	1,100	17.8		18	48	Not	1	Yes	3	Weekly	.60
James Millikan University	450	36	5.6	13	20	1 S. A.	Not			3	Frequently	3.00
Johns Hopkins	1,312	175	13.3		13	144	Not	1	Yes	3	Yes	
Knox College	506	70	13.8	13	22	10	45%	1	No	2	Yes	1.65
Lehigh University	1,039	505	48.6	16	22	192		1	Yes	2 & 3	Yes	6.00
McGill University	2,797	1,000	35.8		15	192	Not	1.5	Yes	2	Yes	
Michigan Agricultural College	1,448	497	33.6		17.5	48	Not	2	Yes	2	Yes	1.00
Northwestern	4,103	211	5.1	4.6	14		Not	2	Yes	2.5	Yes	4.50
Oberlin College	1,528	70	4.6	7.5	12	24		1	Yes	2 & 3	Yes	2.75
Stanford	2,449	250	10.2	6.5	14	100	Not	1.5	No	3	Weekly	
State University of Iowa	4,277	450	10.5	14	15.6	9 S. A.	Not	2	Yes	3	Yes	2.70
State University of Montana	917	25	2.7	15	23	10		1.5	No	2 & 3	Monthly	4.00
Syracuse	4,019	370	9.2	10.8	15.3	15	Yes	1	Yes	2	Yes	
Washington University (St. Louis)	2,308	185	8	6.2	11	84	Not	1.5	Yes	3	Bi-weekly	7.20
Yale	3,664	400	10.9		12.5	288	Not	1	Yes	2	Yes	
University of Alberta	960	397	41.4		14	96	Yes	1.5	No	3	Yes	
Arkansas	797	195	24.5	13	19	14	25%	2.5	Yes	2	Weekly	3.30
British Columbia	952	450	47.3	12	19	None	10%	1	No	3	Twice per term	2.00
California	11,071	1,671	15.1		10	384	Not			3	Weekly	
Chicago	4,682	300	6.4	10	15	336	Not	2	Yes	2	Weekly	
Colorado	2,183	780	35.7		12	6 S. A.	3 hr. wk.	1	No	3	Weekly	.30
Idaho	927	70	7.6	15	17	8	Not	1.5	No	3	Weekly	
Illinois	8,250	750	9.1							2 & 3		
Indiana	2,520	350	13.9	10.4		144	Not		No	2 & 3	Yes	
Kansas	3,452	350	10.1	12	18	108		1.5	No	2	Yes	1.00
Maine	1,270	592	46.6	13	20	None	Yes	1.5	No	2	Yes	1.30
Michigan	8,458	1,146	13.5	13	13	96	Not	1	Yes	2	Yes	.70
Mississippi	620	125	20.1	18	24	24	50%	1	No	2	Yes	5.00
Nebraska	4,411	300	6.8		17		3 hr. wk.	2		3	Weekly	2.00
North Carolina	1,447	280	19.4		15	60	3 hr. wk.	1.6	Yes	2.5	Yes	2.00
North Dakota	1,026	116	11.3	8.7	12	18	Not	1	No	2		5.73
Nevada	467	106	22.7	10	13	48	Not	1	Yes	3	Weekly	1.75
New Mexico	225	26	11.6	10	14			3	Yes	2	Weekly	4.00
Oklahoma	2,713	204	7.5	12	19	6 S. A.	3 hr. wk.	5	No	3	Weekly	25.00
Oregon	2,635	150	5.7	12	14	None	Not	2	Yes	3	Yes	
Pittsburg	2,907	500	17.2	10	15	68	Not	1	Yes	3	Weekly	2.00
Saskatchewan	970	200	20.6	15	20	48	4 hr. wk.	1	No	3	Weekly	3.00
South Dakota	700	36	5.1	5	11	None		2		2	Yes	2.75
Southern California	3,590	300	8.4		15	64		2		3	Yes	1.00
Utah	1,674	267	16	15			Not	1	No	3	Yes	
Virginia	1,630	155	9.5		18	96		2		2	Weekly	
Washington	5,191	460	8.9	15		48		1	No	3	Yes	2.00
West Virginia	1,540	200	13		12	48	Not	3	Yes	2	Yes	
Wisconsin	6,846	1,350	19.7	13	16	96	Not	1	Yes	2	Bi-weekly	1.00
Wyoming	425	62	8.2	18	28	3	12 hr.	1	No	2	Yes	1.50
Mean			13.9	11.5	16							3.41

*S. A. means Student Assistants.

Society, January 29, copied from the March number of the *Michigan Alumnus*. The enrollment of the other institutions was obtained by direct communication with the registrars of the respective institutions. The second table was made partly from data collected in our questionnaire and partly from data taken from the results of a questionnaire made by the University of Utah, a copy of which was kindly furnished us.

TABLE II

University	Number of Full Time Instructors	Number of Courses	Number of Students	Budget for Apparatus	Amount per Student
Alberta	....	....	397	$9,500.00	$23.93
Amherst College	....	....	40	400.00	10.00
Arkansas	2	5	203	3,000.00	14.77
California	11	27	1,660	7,350.00	4.67
Chicago	....	....	300	3,000.00	10.00
Colorado	5	10	750	1,500.00	2.00
Harvard	....	....	400	18,500.00	46.25
Idaho	2	10	70	1,000.00	14.27
Illinois	8	18	750	5,000.00	6.67
Indiana	7	27	350	2,000.00	5.71
Iowa	7.5	12	450	2,500.00	5.55
Kansas	4.5	19	350	2,600.00	7.43
Michigan	21.5	13	1,146	6,730.00	5.82
Minnesota	9	10	850	7,000.00	8.25
Missouri	4	15	350	3,000.00	8.57
Montana	1	12	25	1,200.00	48.00
Nebraska	6	9	300	3,500.00	11.67
Nevada	2	5	106	1,400.00	13 20
North Dakota	3	10	116	1,920.00	16.55
Oregon	3	6	150	2,200.00	16.67
South Dakota	....	....	36	500.00	13.89
Stanford	....	....	250	4,500.00	18.00
Texas	7	24	923	6,000.00	6.50
Utah	....	....	267	1,000.00	3.75
Washington	5	8	460	2,450.00	5.32
West Virginia	....	....	200	2,750.00	13.75
Wisconsin	23	20	1,350	13,000.00	9.63
Wyoming	1	4	60	350.00	5.83
Mean					$12.73

In many cases the data sent in were, of course, incomplete, and in others, due mostly to the fact that different terminology is used in different institutions, the datum could not be used in the table without being misleading. In such cases it was omitted entirely. In making up the table an attempt was made to make the data show the real facts as nearly as possible even at the expense of apparent inconsistencies. For example, the enrollments in the physics departments of both James Millikan University and the University of Wyoming includes a high school class which the departments were obliged to take care of while the percentages of the university enrollments taking

physics are based upon the number of students in the university classes only. The total enrollment of each institution includes, so far as could be determined, only regular university or college students.

The data in Table I are from fifty-one representative institutions in the United States and Canada with a total enrollment (omitting the Carnegie Institute of Technology) of 129,210 students of which 17,944, or 13.9 per cent, were taking physics. The four Canadian institutions are probably as nearly representative of the institutions in that country as the others are of those in the United States. If the data for these are segregated, there is 13.0 per cent of the total enrollment taking courses in physics in the United States and 36.4 per cent in the institutions of Canada. This marked difference is due in the greater part to two things; first, to the physics requirement for liberal arts freshmen in most Canadian institutions, and second, to their requirement (much to their credit) of two years of physics for all applied science students (engineers) corresponding to the one year of general physics, given in most institutions in the United States. There are a few institutions in the United States whose percentage enrollment in the physics department is rather high. Some of these are easily accounted for, such as the Case School of Applied Science, and the Iowa State College which are technical schools and whose courses require physics in nearly every case. Three of the most remarkable instances in respect to the large enrollment in the physics department are Lehigh University which outranks all others including those in Canada, and the Universities of Maine and Colorado. To some extent the variation of the percentage of students taking physics may be accounted for by the variation of physics requirements in the technical courses. For example, the University of Wyoming does not require physics in either the courses in agriculture or home economics, while most other institutions have such requirements.

The terms "credit-hour" and "teaching-hour" were not understood in every case because in many institutions these terms are not used. In many institutions in the United States a certain number of credit hours are required for graduation. If a class meets three times per week for three lectures or quizzes then the student receives, in most institutions using this system, three hours credit, and if the instructor has four such classes, he would have twelve credit-hours work per week. If the

class meets three periods of one hour each per week either for lectures or recitation work, and two laboratory periods each of two or three hours in length then this course would constitute five hours credit for the student and five credit-hours for the instructor. If the laboratory periods are two hours each, such a course would require seven teaching-hours for the instructor; and if the laboratory periods are three hours in length, nine teaching-hours for the instructor.

From the tables it will be seen that the average number of credit-hours for thirty-four institutions is 11.5 and that the average number of teaching-hours for forty-six institutions is 16. In connection with these two columns it is well to study the answers to the question: "To what extent are the instructors in your department overloaded?" With few exceptions it will be seen that where the instructors' teaching-hours exceeded sixteen the one who answered the questions considered that the instructors in the department were overloaded and usually to about the extent of the number of hours exceeding sixteen. A note in the questionnaire asked that time for research work be not considered. In a few cases an overload was reported when the teaching-hours were sixteen or less, and in other cases a note was attached saying that there was not enough time for research.

From a careful study of the answers of these questionnaires one would have to come to the conclusion that in general when teaching-hours exceed sixteen any excess of that number may be considered an overload for the instructor for institutions that expect their instructors to give their full time to their teaching with no allowance for research, and that any institution that favors research should cut the number of teaching-hours below that number. The actual amount of time required of an instructor to do his work efficiently will, of course, depend upon the conditions under which he is working such as efficiency and organization of the laboratory, organization of the courses and the completeness of lecture apparatus, amount of non-teaching help, and the number of assistants in the department. It makes a vast difference whether the instructor has to prepare and adjust apparatus for laboratory and lectures and correct his own reports and test papers outside of teaching hours or whether he has enough assistance so that reports may be corrected during the laboratory periods, and to set up and adjust apparatus so that these details will require but little of

his time and attention. It is probably not overestimating it to say that if the work is done efficiently an instructor must put in from two to four times as much time outside of the actual teaching hours that he does in the lecture and laboratory periods depending upon the conditions mentioned above. At any rate if the answers to the questionnaires can be considered as a guide (and who can ask for better authority?) sixteen teaching-hours would be considered a fair load without considering time for research.

While the number of credit-hours does have as much significance as the number of teaching-hours in many university courses, it is evident that it can have very little significance in the department of physics. It was included in the questionnaire because of the tendency of instructors of non-laboratory courses and administrators to expect instructors of science to carry the same number of credit-hours as other instructors without any idea as to the time necessary to do the work efficiently.[2]

In connection with what has just been said it is interesting to study the opinion of teachers of physics in their answers to the question: "In your opinion, where part of the work is laboratory instruction including the setting up of apparatus and correction of papers, how many laboratory teaching hours are equivalent to one teaching hour in other non-laboratory branches of university instruction?" It wasn't intended, of course, to compare a laboratory hour with an hour of formal lecture in chemistry of physics where, if the lecturer has to prepare the apparatus as well as the lecture, several hours of preparation may be required besides another half hour to an hour to remove the apparatus, but it was intended to compare a laboratory hour with lecture and recitation hours where no apparatus is required. However, this question was not so interpreted in some cases. The following comments are interesting:

"There are so many things to be considered it is useless to make a general statement without making several qualifications." (Stanford University.)

This question "does not apply to us as the setting up is done by a helper, and the reading of papers by readers and assistants." (California.)

"It all depends upon whether or not an instructor is content by doing

[2]A head of another department once remarked to the writer that the reason for the large number of teaching-hours in the department of physics was that the laboratory work required no time of the instructor except that actually put in while the students were present, and another member of the faculty, finding the writer devoting a couple of hours to a set of apparatus with which students in a previous laboratory period had failed to get results, lamented the fact that he had not the time to "play" with such things.

things year by year in the same old stereotyped way or whether he is continually changing his course and devising apparatus for his work. At Indiana we do the latter." (Indiana.)

"Hour for hour, up to twelve hours per week. Many instructors would prefer eighteen hours mathematics or modern language to eighteen hours physics laboratory." (Pittsburg.)

"Ought to be hour for hour. Here two to one." (Washington, Seattle.)

"One hour of laboratory teaching is more exhausting than one hour of class room work if the laboratory is carried on properly." (Oberlin.)

"I consider laboratory instruction fully as valuable, and quite as wearing upon the teacher as non-laboratory instruction." (Knox College.)

"One and one-half hours laboratory is about equivalent to one hour elementary recitation. Two to three hours laboratory are about equivalent to one hour formal lecture." (Case.)

"One to one if the laboratory work is well done." (British Columbia.)

"Laboratory instructors do more in proportion than non-laboratory teachers." (Colorado College.)

"Including preparation in non-laboratory branches the two are equivalent hour for hour." (Nevada.)

"Personally I see little difference. I would say hour for hour whether actual teaching or preparation." (Mississippi.)

"In introductory courses it is about hour for hour, but in advanced graduate courses it takes two or three laboratory hours to equal one lecture hour." (Oregon.)

Of the forty-five answers to this question twenty estimate one hour of laboratory instruction equivalent to one hour of instruction in non-laboratory subjects; eight estimate 1.5 to one; one, 1.6 to one; twelve, 2 to one; one, 2.5 to one; two, 3 to one; and one, 5 to one. It is probable that the one who made the last answer had in mind a formal lecture in physics which would very easily be equivalent to five laboratory hours, especially if the instructor was obliged to set up the apparatus himself. In the tables Oregon was classed among those who estimated two hours to one. It would probably be fairer to place Oregon among those favoring hour for hour since the writer had in mind undergraduate work when the question was written as very probably others had when they answered the question, but the general scheme of making up the table required that Oregon be placed where it is.

These answers show that the universal opinion of physics teachers in colleges and universities is that it is necessary to give careful and pains-taking instruction in the physics laboratory—especially in the elementary courses. These answers are from men who know from experience the work required to set up, adjust and keep apparatus in shape for laboratory work in physics as well as the time required to correct reports, and to others who know nothing of this either by experience or otherwise, the study of these data may be illuminating.

A study of these reports shows that it is an almost universal practice to correct laboratory reports as soon as possible after they have been submitted. This, of course, is necessary if the student is to profit by his mistakes. A comparison of the answers in the table is perhaps not quite fair to some institutions since, as in the case of Stanford University, some institutions are reported as correcting laboratory reports weekly, and while this is approximately true yet the reports are corrected in the laboratory which method is probably better for the department and better for the student even though in some cases reports may go over a period without being corrected. Other institutions have a system of checking up reports the same day the exercise is worked before the students leave the laboratory. Where the instructor's time is very largely taken up in assisting students and in teaching, either of these methods is not practical, and the next best thing to do is to return the corrected report to the student at the beginning of the next period. The answers in the questionnaires show that nearly all of the institutions reporting follow one of these three methods.

The data in the last columns of Tables I and II are misleading unless a study of the other conditions of the departments is made in connection with them. Where the institutions are about the same size and working under about the same conditions one may reasonably make a comparison between two of them, but comparison between the datum from a large institution and that from a small one is hardly just and to the disadvantage of the larger institution in most cases.

Institutions which do a large amount of research work do not segregate funds used for laboratory and lecture apparatus from funds used for research apparatus. On the other hand such institutions as well as the larger institutions regardless of the extent of their research activities usually have from one to three instrument makers at work throughout the year repairing and making new apparatus. Funds from which the salaries are taken to pay these skilled workmen are not classed under budget for apparatus. The material, however, from which they make the apparatus may be purchased from the apparatus budget. Therefore while these institutions may have a budget of from five to fifteen dollars per student, or even more, this amount does not nearly represent the actual expenditure for apparatus, and does not for this reason represent the efficiency of the department in this particular.

A comparison between institutions is deficient also in that an expenditure per student, or per student-credit-hour, may not give a correct idea of expenditure relative to the actual needs of the department in any particular institution. It is quite obvious that in order to be as efficient in equipment for the same work the small institution needs a larger expenditure per student than does the larger one. In some cases, especially for lecture demonstrations, one piece of apparatus of a certain kind may be adequate for the department no matter what the enrollment may be. In this respect the department with the large enrollment could equip much more efficiently with the same budget per student than can the department with the small enrollment.

The last column of Table I was obtained by multiplying the number of students in the class by the number of credit hours for each class and dividing the sum of the numbers thus obtained into the total budget. To compare these quantities with the quantities in the last column of Table II, we find that in Table I the number for the University of Wyoming is 40 per cent of the average while for Table II it is 45.8 per cent of the average. This shows that roughly the two tables show about the same results. However, both of the tables include only thirteen out of the twenty-eight institutions listed in the last column of Table II and of the thirty-one institutions listed in the last column of Table I. The enrollment given is not the total enrollment, but the enrollment for the fall of 1920 and this makes all quantities larger than they would be for the total enrollment.

What bearing has such data as is here given upon the life of an institution? What interest ought the institution to have in such a study? The basis of the thought in this paragraph was taken from the dozen or so letters received supplementing the questionnaires and from the notes added to the answers upon them. It is quite obvious that if an institution wishes to keep in the front rank, besides the other things that make for quality such as equipment, it must employ first class men as instructors—experts in their line. But this alone will not do, it must keep its instructors in that class. In order to be in the first class a man must not only possess ability to instruct, but he must be thoroughly posted in his own line, and in order to keep in that class he must keep posted and keep up his enthusiasm. In a subject like the one under discussion with the physics of today

so far in advance of the physics of yesterday a man must work constantly and hard to keep up; and so far as research is concerned he may not, for lack of time or other reasons, be able to add much to the world's knowledge, but a little research is worth while for what it may add to keeping up enthusiasm and for the benefit it gives to his ability as an instructor even if it turns out to be good for nothing else. It is obviously poor policy for an institution to allow conditions which will hinder its instructors from keeping in the front rank for just in the proportion that the instructor retrogrades in the same proportion will the institution retrograde.

To summarize, our study shows:

That there are thirteen per cent of the enrollment in higher institutions of learning in the United States taking physics and over thirty-six per cent in Canada.

That the average credit-hours for physics teachers is 11.5—less than the minimum requirement at the University of Wyoming, but that the credit-hour is a poor criterion when applied to such a subject as physics, or any other laboratory science.

That the average number of teaching hours is 16, and that this seems to be considered a full load where no research is contemplated. Also that it is evident if institutions like Wyoming and Mississippi which carry abnormal loads and others like Saskatchewan and Oklahoma which are reported as temporarily over-loaded, and a few of the technical schools which, because of the increasingly large classes, are obliged to carry abnormal loads be eliminated the average would be below 16.

That the amount of work required of an instructor will depend also upon the conditions in the department such as amount of non-teaching help, laboratory assistance, efficiency of organization, etc.

That many consider laboratory work, taking into consideration preparation and correction of reports, equivalent hour for hour to instruction in non-laboratory courses, and the average general opinion is that about one and one-half hours of laboratory work is equivalent to one hour instruction in a non-laboratory course; or in other words, one three-hour laboratory period is about equivalent to two periods of instruction in a non-laboratory course, provided of course, that neither instructor has an excessive number of teaching-hours.

That three-hour laboratory periods are prevalent, while some reports had a note added that a two-hour period was too short

in cases where their report showed a two-hour period.

That while the average budget per student is over twelve dollars, for smaller institutions having no instrument maker it ought to be somewhat in excess of this amount if these institutions expect to do work as relatively efficient as the larger institutions.

That instructors of science in all institutions of university class ought not only keep abreast the times especially in their own subject, but should carry on some research work in order to keep in the front rank of ability as an instructor.

THE RESPONSIBILITY OF A TEACHER.

No matter what our work in this world may be, each and every one of us has a duty to perform. Whether we are builders of bridges, sailors of ships, transporters of food or cleaners of streets, we assume a solemn obligation to our fellow men. If we fail in our responsibility, some one, some how, may suffer.

Someone, somewhere, is responsible for the thousands of misfits, human failures and ne'er-do-wells we meet on every hand. A little careful observation with a word of advice may have saved many of those unfortunates to lives of usefulness in a needy world.

In the classrooms of our educational institutions, the lives of our future citizens are moulded. It is here that one of the greatest responsibilities to mankind is accepted. It is here that physical and mental errors may be quickly detected. It is from here that the warning should be given to parents of children who are otherwise too occupied to notice the first symptoms of physical defects. It is here that the ground work must be laid for building up strong men and healthy women; men and women who can go out into the world fit to fight the battles of life with vim and vigor.

It is not the object of this article to go into the many problems being faced every day by teachers all over the land who are so conscious of duty to humanity. The main thought is to point out only one phase which seems to have been, to a great extent, overlooked—the care of the eyes.

There are millions of school children in this country with defective eyesight. You have some of them in your classroom. They may be those you call "lazy" or "stupid." A word of advice to their parents may help to relieve you of much worry.

Watch the way your pupils use their eyes! Do they tilt their heads? Do they hold the book too near the face? Do they let the book lie upon the desk and stoop over it? Do they twist the body around when reading? When they have to look up, either at you or at the blackboard, do they screw up their eyes and seem to squint? Do they get drowsy even when the room is well ventilated? Do they rub their eyes or their foreheads or wink or blink when they have to read aloud? These are all symptoms of eye-strain that should be recognized and receive prompt attention.

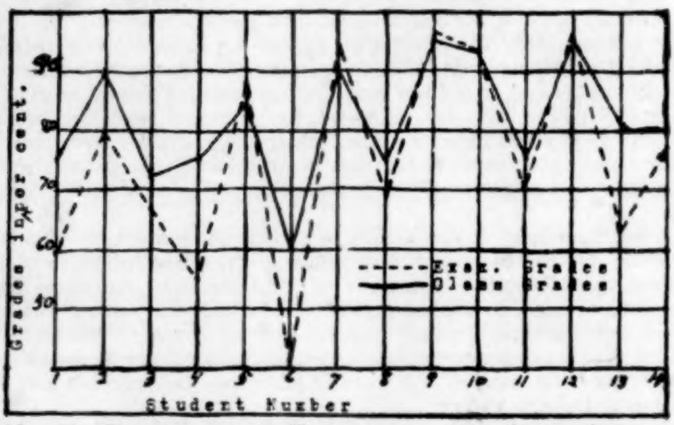
Each teacher will find it helpful to test the eyes of pupils by using, for preliminary examination, a Vision Chart for Schools, which will be supplied upon application to the Eye Sight Conservation Council of America, Times Building, New York, N. Y.

TECHNIQUE IN CHEMISTRY TEACHING.

By H. A. Cunningham,
Community High School, Paxton, Illinois.

We have heard much, during the last several years, about the poor science teaching that is being done in our secondary schools. The feeling of the greater per cent of school men may well be expressed in the words of Dr. Snedden, who said: "Educators generally who look broadly into the field of secondary education must experience a sense of disappointment as to results now achieved through science teaching." It has become the writer's conviction that much better results can be secured if more time is spent in working out an effective teaching technique.

At the beginning of the last school year, 1920-21, the writer started with a class of fourteen seniors in high school chemistry. The class, as a whole, was made up of students of very ordinary mentality and intellectuality. Four were above the average, judging from their high school grades, and seven were much below the average.



No. 1. Comparison of Examination and Class Grades. Mid-Semester Grades of the First Semester

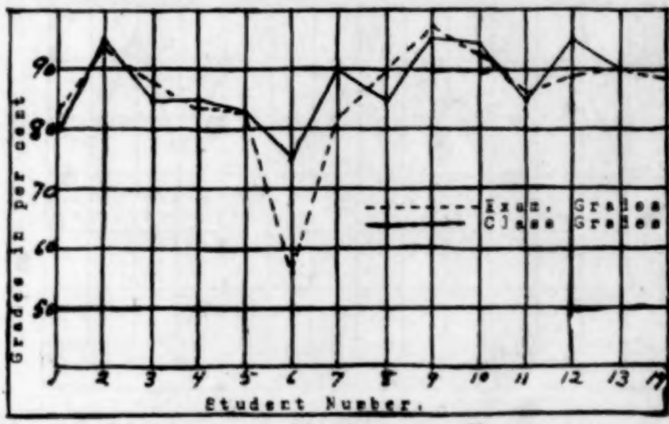
During the first semester, the work was carried on in the old "proverbial way:" three days of recitation upon a certain number of pages from the text, and two double periods for laboratory work, each week. An effort was made at all times to correlate the laboratory work with the text. The text used was, Hessler and Smith, *Essentials of Chemistry*.

Very unsatisfactory results were obtained, from all but the very best students, from the start. It will take but a glance at the solid line in graph No. 3 to tell that, by the time the semester

was half over, things were not going well. The results in daily work were poor enough, as indicated by the solid line in graph No. 1. Grades from the mid-semester examination, however, as indicated by dotted lines in graph No. 1, showed conditions to be even worse than the daily grades indicated.

Daily grades and examination grades at mid-semester time are given, rather than the daily grades and examination grades at the end of the semester because, under the exemption plan in use at Paxton, many are exempt from the final examinations at the end of the semester. Some are exempt on a grade as low as 82% if their attendance and deportment have been perfect. Every one, however, takes the mid-semester examination.

The writer did everything within his power, that was consistent with the "three recitation and two laboratory periods plan" and with the very conservative traditions of the school, to bring that class up before the end of the semester. The solid line in graph No. 4 shows that he was only partially successful. At that time six of the fourteen were barely passing, one had



No. 2. Comparison of Mid-Semester Examination and Class Grades for the Second Semester

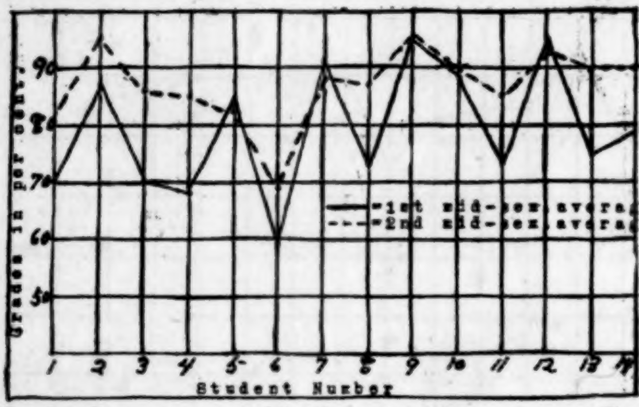
failed, and seven were doing more or less well. Two of the seven were doing exceptionally well. Those two, however, were such exceptional students that they would have gotten chemistry without a teacher.

The examination grades, at the middle of the first semester, indicated, as many examination grades do, that fundamental principles were not understood. During this first semester, there was failure to get the important principles unified and their meaning and importance crystallized, in the pupils' minds.

Pupils may get lessons day after day and still fail to acquire such a mastery of the subject that will give them real power in it. For all but the best three or four students of the class, time spent outside of the recitation period in preparation of a textbook lesson was practically wasted. No better example of the ineffectiveness of home and outside study, for the average or poor high school student, has ever come under the observation of the writer.

In the face of such a situation we felt justified in taking a radical departure from the customary practice and in endeavoring to develop a more effective teaching technique. The most valuable helps in this development have come from a course, taken at Chicago University under Professor Henry C. Morrison, entitled "Principles of Technique of High School Instruction," and from a study of the system that has been in use at New Haven, Connecticut, during the last ten years.

In the first place, the requirement of the preparation of lessons in the descriptive text was discontinued. Two double



No. 3. Comparison of Mid-Semester Averages for First and Second Semester

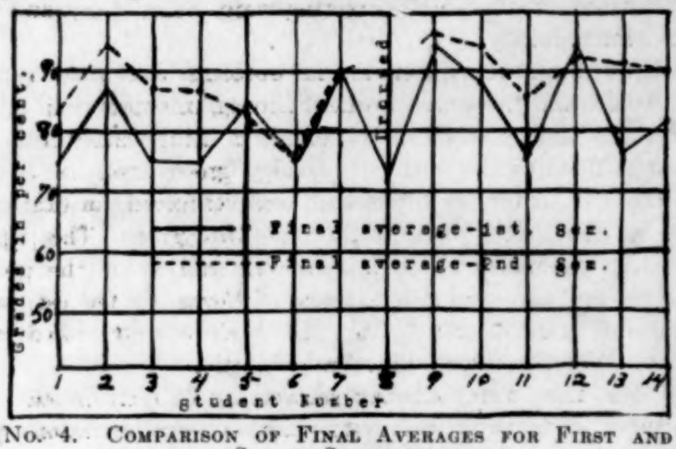
periods, eighty minutes, were used every day and no work outside of class was required. The different chemistry texts and the books related to chemistry were withdrawn from the school library, and were placed upon a table in the chemistry room.

A topical analysis was made of the material yet to be covered in the course and each topic was taught as a whole. Under each topic, the minimum essentials, which all must master, were determined. In general, each topic was taken up in the following manner.

Each new topic was opened by a short lecture, by the teacher. The object of this introduction was: (1) to connect the new topic with what the pupil already knew about the subject; (2) to give necessary information so that the pupils would attack the topic properly and without the loss of valuable time; (3) to arouse interest by giving information concerning the practical applications of the principles involved and by making reference to things of historical interest in connection with the topic; (4) to agree upon an outline of the minimum essentials which every one must master.

If the teacher puts much study upon his part in the introduction, it can be made very effective. This is the teacher's opportunity and he must be prepared and alive to the situation. If this introduction is not well in hand, it will likely do more harm than good.

Next came an exhaustive study of the topic in laboratory work and in supervised study. No formal recitation work was attempted during this time and this stage generally lasted several



No. 4. Comparison of Final Averages for First and Second Semesters

days. The course was really an exhaustive study of the laboratory work.

As a general thing, this assimilation period was started by beginning with the laboratory work. Some, however, preferred to read a little on the topic before starting the experiments. As the laboratory work proceeded, definite references were given to pages and sections of the various texts bearing upon every phase of the topic under discussion. During the laboratory work and after its completion, exhaustive reference work

was done by each student, using the references as a guide. Such references often showed them the necessity of doing part, and sometimes all, of their laboratory work over. Reference was given to any theory that was necessary for a thorough understanding of the topic. Hessler and Smith's laboratory guide was used for laboratory work because each pupil had a copy of this text.

All experiments were written up under three heads: (1) what was done; (2) what happened; (3) an explanation of why it happened. Part one was a reference to directions given in the laboratory guide and included any alterations or additional directions given by the instructor. Part two was made up of very brief sentences giving just what was seen in the experiment. Part three was a lengthy discussion of the reactions that took place and included the equations for all reactions.

When the student had finished writing up the experiment it was generally gone over by the instructor immediately. Often the pupil and instructor went over the paper together. In this way mistakes that needed correcting were pointed out and corrected immediately.

A list of important questions and problems were made out for each topic, and these were worked through in supervised study. When the topic had been mastered, or nearly mastered, the students filled in the outline, formerly agreed upon, as a brief or syllabus. After the briefs had been completed, an examination, covering every phase of the topic, was given. The papers from this examination were immediately graded and the points upon which there was still haziness as shown by the test, were gone over again in class. Then the briefs were reviewed with the idea of getting ready for a real recitation.

By this time every one had something to recite about. In this phase of the work each pupil made an oral recitation upon some topic, or subtopic, requiring a rather lengthy discussion. At the end of each recitation, the other members of the class had the liberty to ask the pupil, who had just recited, questions, to correct him, or to make an additional contribution to the topic under discussion. Sometimes the skeletonized outline was placed on the board and the pupils recited from it. Fundamental problems, bearing upon the topic, were solved in full on the board by some members of the class and a detailed explanation given as their contribution to the recitation period. The number of mathematical problems, however, was reduced to the minimum.

This form of recitation affords one of the best opportunities to give training in good oral English expression.

By referring to graph No. 3 we see that by the middle of the second semester the grades were being improved. At this time the class had an average of 87% against an 80% average at the middle of the first semester. It is interesting to note that in only three cases were the averages at the middle of the second semester lower than the averages of the same students at the middle of the first semester. This can be satisfactorily explained by the fact that these three were not able to attend class for the regular double period of work but attended only one period at the regular class time and worked another period later in the day. This put them at a disadvantage and made it impossible for them to get the full benefit of the new technique.

Graph No. 2 shows that the results from the mid-semester examinations compare much more favorably with the class grades. All tests during the year were built with the idea of testing their understanding of fundamental principles and ability to use them. The results at the middle of the second semester tend to show that understanding and power were being gained much better than during the first semester.

The final grades for the two semesters, as shown in graph No. 4, indicate that much better results were obtained during the second semester. In only two cases, No. 5 and No. 12, were the averages lower for the second semester than for the first. It will be noted that these were two of the three who could not attend class for the regular two periods of work. The other pupil, No. 7, who was thus handicapped made the same average score for each semester. The total class average for the first semester was 81.7% and for the second semester 89.1%. As far as grades were concerned, we see that the change in technique was entirely worth while. Let us look briefly at some of the other advantages that came from the change.

One of the main benefits of the change was the fact that the teacher had control of the learning situation at all times. For the weaker students this meant a change from discouragement to a consciousness of the fact that they really could learn chemistry. This brought a new interest to the subject and the requests to work in the laboratory at vacant study periods and after school became frequent. While no outside work was required, much of it was done on special topics and several reports of results of outside study were voluntarily given to the class. Student No.

4, a very unpromising lad during the first semester, made requests at three different times during the second semester to report to the class the results of special work done. This work upon special topics was given to those who completed the work upon the assigned topic sooner than some others. Some qualitative analysis was taken up during the second semester and students had an unknown at hand upon which to work when they had completed the work, upon the regular assignment, earlier than some others in the class. This makes the course elastic enough that the weak and strong student will each get the proper amount of work. In this connection, it is interesting to note that students No. 1, 3, 4, and 11 who were low during the first semester, each completed as many unknowns as any member of the class.

The distinguishing features of our change in technique are: (1) the abolition of required home, or outside study; (2) the adoption of a longer period for class work; (3) the abolition of the assigned lesson from a text book to be prepared at home or in the study hall and hashed over in recitation; (4) the basing of the entire course upon an extensive laboratory and reference study of certain units of subject matter; (5) a topical analysis of the course, at the beginning, into teachable units and the mastery of each unit as a whole.

THE VALUE OF VALENCE AND WHEN TO TEACH IT.[1]

E. E. Rademacher,
Nokomis, Ill.

In chemistry as in other science there are, in the main, two things to be considered: Method and results. There is no doubt an enormous mass of facts from which we have to select the indispensable things for the beginner, and again there is the general procedure or method by which those facts have been ascertained.

First: The real value of valence to the student.

It is not my object to discuss this part of the question as fully and in such detail as the second part of the question. The writers of chemistry texts do in general agree as to the value of valence although some give to this subject more space than others. No text gives enough drill on this important subject.

Valence is not a fact. It is an attempt to arrange the facts of our science according to the idea of combining power, just as books are classified in a library to subjects. One of its chief values is to assist the student in becoming familiar with the

[1]Read at the University of Illinois Conference, November, 1921.

formulas of the compounds; how and why they are written as they are. We all know the subject of chemistry is filled with formulas and equations and it stands to reason that we should devote the proper time to a subject, which assists the student directly in becoming familiar with this something that stares him in the face almost every time he turns a page. If the student knows valence he can reason the formula of a new compound. If he does not know valence, he must first be told what the formula is and then must simply memorize it.

Valence is the backbone of chemistry. Without valence you are a chemical corpse. Without valence you cannot write formulas, without formulas you cannot write equations. If you cannot write equations it is impossible to either predict or understand chemical changes. If you cannot write equations you are at a loss to solve problems. If you do not know these fundamentals of chemistry you are minus the principles of chemistry; you lack the foundation upon which the chemical world is built.

Second: When to teach valence.

This is a problem that many teachers as well as writers of chemistry texts disagree upon. The main difference comes in trying to answer the following question: Should valence be taught before or after formulas and equations? The writer has tried both methods. When valence was taught *after* formulas and equations, the student seemed to be puzzled throughout the entire course in writing formulas and equations. A test on this was made from two of my classes in chemistry. Fourteen students averaging about the same grades in various sciences were divided into two sections, Section A and Section B. To the seven students in Section A, valence was taught before formulas and equations and to the seven students in Section B, valence was taught after formulas and equations. Please remember that pains and interest were taken in both sections to make the three subjects, valence, formulas, and equations clear. After giving five recitation periods of instruction to each section, the two sections were united and given a quiz consisting of the writing of twenty formulas and twenty equations.

Out of one hundred seventy-five letters mailed to different chemistry teachers over the state, 83 replies of a definite nature were received. Personal letters were not requested but 14 personal letters were received, expressing their experience as to the teaching of valence. In thirty-eight of the replies, the

TABLE I.

Section A.

Total Formulas and Equations	Right	Wrong	% Right
Formulas.......140	127	13	90.7
Equations.......140	121	19	86.4
Average			88.5

Section B

Total Formulas and Equations	Right	Wrong	% Right
Formulas.......140	102	38	72.8
Equations.......140	93	47	66.4
Average			69.6

writer expressed his or her desire to have the proceedings and general data from the discussion on this topic sent to them as they would be unable to attend the convention, but were intensely interested in the subject.

More interesting conditions are revealed as the answers to the eight questions are compiled.

TO CHEMISTRY TEACHERS WHO ARE EITHER TEACHING OR WHO HAVE TAUGHT CHEMISTRY.

It is with particular interest that I am sending you this questionnaire and I hope you will cooperate with us in discussing this great problem, "The Value of Valence and When to Teach It." You will note in the State High School Teachers' Convention to be held at Champaign, November 18, that this is the topic for discussion in the Chemistry Section.

Let me urge you to be present and be prepared to give us your viewpoint on the subject.

May I ask you to please fill out the blanks in the questionnaire and return them to me at once in the self-addressed and stamped envelope?

I wish to thank you in advance very much for your cooperation.

I assure you that your efforts will be worth while and that we will all benefit by it.

The Value of Valence and When to Teach It.
Questionnaire.

1. Do you teach valence before or after equations and formulae?..........
2. Why?..........

3. Do you find it difficult for the average pupil to understand valence?
4. What textbook are you using in chemistry?..........
5. Is valence placed in your textbook before or after equations and formulae?..........
6. Will you try and be present at the State convention and discuss this problem with us?..........
7. To what extent do you use atom models for making the conception of valence clear?..........
8. What methods do you use for keeping the idea of valence constantly in the mind of the student?..........

Your name..........
School..........
Address..........

Space does not permit a detailed list of the answers to the questions which were asked in the questionnaire and for this reason the answers have been briefly summarized as follows:

Question No. 1.—"Do you teach valence before or after equations and formulae?" Of those who replied, 33 answered "before;" 26 answered "after;" 18 answered "together;" 4 answered "with formulae and before equations;" and 2 answered "after formulae and before equations."

Question No. 2. "Why?" Of those who replied "before equations and formulae" there were about fifteen who believed that it was impossible to understand formulae and equations without knowing valence. Four felt that valence, when taught first furnished the answer to questions as to why AgCl and $BaCl^2$ are written in this particular manner and no other. Two considered the memorizing of the valences of the more common ions and then applying them to the formulae as being easier than memorizing the formulae themselves. Five found that this method served as a direct help in understanding formulae. One reason as given was that without valence you cannot write formulas, without formulas you cannot write equations; if you cannot write equations you cannot predict or understand chemical changes. Also without equations you cannot solve problems. And without these you do not know chemistry nor the principles of chemistry and have no foundation to build upon. Hence this person teaches it before. Another teacher gives a simple talk on valence in the beginning of the course and works it in so that the students understand it thoroughly by the end of the first month. A number gave no specific reaon for their answers.

Those who teach valence after equations and formulas submitted the following reasons: Ten thought the learning of formulae and their subsequent use in illustrating valence to be the more logical way. Three believed it better to wait till the

learning of equations and formulas caused the students to ask why the elements united in a definite ratio and then use valence as the answer to his question. Two considered that observation came before equation and hence there was no need for valence till there was something to apply it to. One reason given was that formulas learned first gave a visual aid in writing correct formulas using the valence when it was taught. Another chose to follow the discussion of the Atomic theory with the presentation of valence.

Some taught all three together and the reasons given for this method somewhat overlap those given for the other two methods. They are: Equations cannot be balanced and understood without the conception of valence being introduced simultaneously. Four gave this reason. Three gave their reasons as being the fact that this method gave a better and clearer idea of equations. Another considered it impossible to separate the three in teaching them.

Question No. 3. "Do you find it difficult for the average pupil to understand valence?" 42 replied "no;" 29 replied "yes;" 11 replied "rather," and one replied "depends on the teacher and the text."

Question No. 4. "What textbook are you using in chemistry?" The summary of the answers to this question is: Using "Brownlee and others," 36; using "McPherson and Henderson," 17; using "Alex. Smith," 11; using "C. S. Dull," 6; using "Smith and Mess," 4; using "Morgan and Lyman," 2; using "Hessler-Smith," 1; using "B. F. H. S. and W.," 1; using "Newell," 1; using "mimeographed references," 1; using no book, 1.

Question No. 5. "Is valence placed before or after equations and formulae in your textbook?" 35 replied "after;" 29 replied "after formulas and before equations; 10 replied "before;" 4 replied "together," and 5 did not answer.

Question No. 6. Not relative to the paper itself.

Question No. 7. "To what extent do you use atom models for making the conception of valence clear?" About forty do not use models, while some use various types of models. Diagrams and structural formulas are used to some extent by several replying to this question.

Question No. 8. "What methods do you use for keeping the idea of valence constantly in the mind of the student?" It was found that twenty-two simply refer to it constantly in taking up new formulas and equations and in reviewing the old ones.

Twenty-one use frequent drills in formula and equation writing. Regular review with quizzes was the plan followed by seven and another group of seven used structural formulas throughout the work. Other methods used are: prediction of formulas and equations by valence; use of valence in problems and equations; use of tables of valences in class work; writing the valence of each element in every reaction studied. One teacher made use of frequent reference to his own experience in practical industry showing the value of valence in that connection.

You will notice from the data given that nineteen who teach valence after formulas and equations find it difficult for the average pupil to understand and seven do not find it difficult Twenty-four who teach valence before formulas and equations do not find it difficult for the average student to understand and nine find it difficult. Eleven who teach the three together say "no," and seven say "yes" to the question. Two who replied "with formulas and before equations" say "no" and two say "yes."

From the replies received you will notice the great difference of opinion on the various questions. Attempts should be made to get together on the methods of teaching valence and its connecting topics. You will agree that the various texts differ extremely as to the order of presentation of these topics. It is true that we all have our individual opinions, but there should be one logical order in which to develop the entire subject.

A LESSON IN FLUID PRESSURE.

By John V. Jewett,
Brookline, Massachusetts, High School.

In general science and also in junior physics classes the arrangement of apparatus before the pupils combined with the Socratic method of discovery will hold interest and consequently instruct more thoroughly than a prearranged demonstration wherein the pupil tries to prove results in exact figures only to find that things do not seem to work as they ought. After my pupils had worked with me in the following manner they welcomed Pascal's Law as a fact that they had discovered. I claim no perfection in the following arrangement, but I do claim for it a correct method.

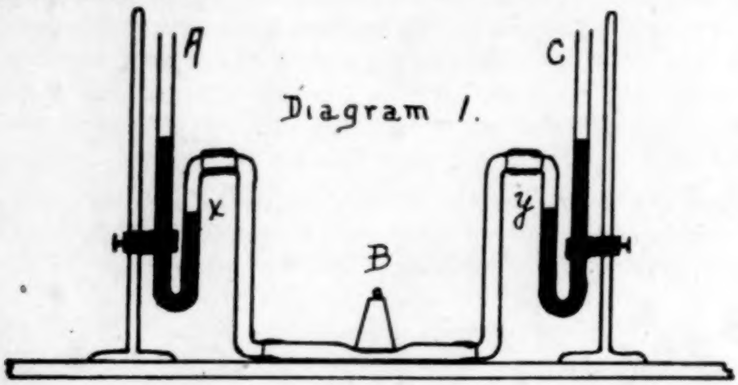


Diagram No. 1.

Apparatus.

Constructed in class. Two pieces of glass tubing each end bent at right angles and joined by a piece of soft rubber tubing. Two U-tubes, A and C, joined by tubing and supported by ring stands as shown. Weight B. Colored water (red) drawn in to some convenient level as x y.

Development.

What is in the tube? Colored water. Is the pressure at x and y the same? Yes, one atmosphere. When B is placed on the tubing what happens? Water rises in A and C. Does it matter at what place on tubing B is put? No. What causes water to rise? Pressure exerted by weight B. How does pressure reach A and C? Through the water. What indicates the amount of pressure? The height of water above xy. In which tube is water higher, A or C? Same height in each. Which receives greater pressure? Pressure must be same. In

how many directions is the pressure transmitted? Two. Would result be same in other directions? Yes. What do you conclude regarding pressure applied to a confined liquid? Pressure is transmitted equally in all directions.

PRACTICAL APPLICATIONS.

If B represented the place where a pump applied pressure to the city water system, would you receive more pressure at your faucet if your house was located at x? No, because pressure would be same at y or any other outlet.

Hydraulic press, elevators and dentist chairs discussed.

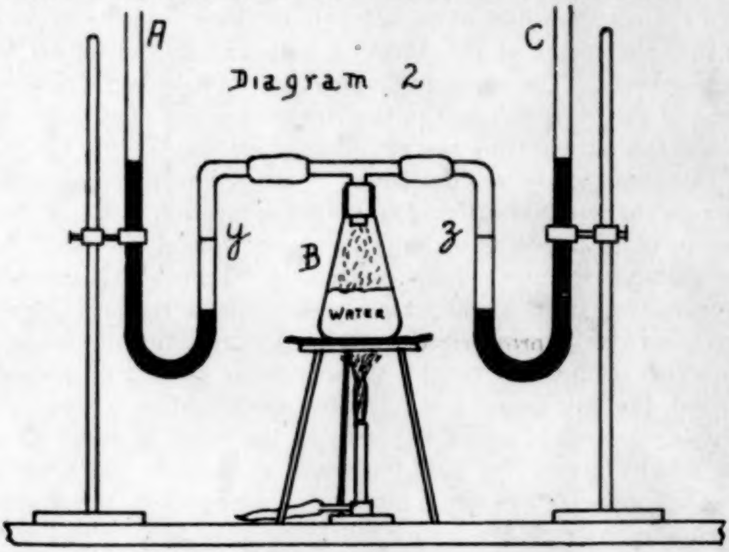


DIAGRAM NO. 2.

APPARATUS.

Arranged before the pupils. Flask B 1–3 full of water, tripod, gauze, burner, one hole rubber stopper fitted with brass T-tube connected to two glass U-tubes as shown. The U-tubes filled with red water at levels y, z. Water brought to boiling point before stopper is inserted and then flame is removed. Heat occasionally applied to keep up pressure as needed.

DEVELOPMENT.

Does steam exert pressure? Yes. What is in tube between y and z? Air. If the stopper is placed in flask will the confined gas (air) receive pressure? Yes, from the steam. What happens in C when stopper is put in flask? Water rises. How high above z? Four inches. What happens in A? Water rises.

How high above y? Four inches. Does the air push the water up? Yes. Where does the air get its pressure? From the steam. What does this show regarding pressure applied to a confined gas? Pressure applied to a confined gas is transmitted equally in every direction.

STRENGTHENING HIGH SCHOOL SCIENCE TEACHING.

HENRY FLURY,
Eastern High School, Washington, D. C.

The teaching of high school sciences is unsatisfactory. That is a bald statement, and one that should be allowed to soak into the consciousness of all teachers of those subjects as well as into the cortex of the directing authority in control of the high schools. The same indictment may be brought against some of the other subjects in the curriculum, but that does not relieve the burden from the shoulders of science.

This condition is well illustrated in the report of the commission on the reorganization of secondary education (1920) in the statement: "There is widespread recognition of the need for reorganizing science courses in secondary schools. Numerous encouraging efforts already have been made to redirect, enrich and otherwise improve these courses. The variation of purposes for which sciences are taught, the increasing number of sciences offered, the development of intensive specialization within various sciences, the lack of sequence in the order in which they are usually given, the wide variation in methods and content are striking evidences of the need for an approach to agreement. Each science course needs such redefining as to purpose and such rearranging of materials, as will bring it into harmony with valid principles."[1]

An investigation of the causes of this condition reveals the following:

1. The sciences are comparatively new in the history of education. They were not included in the old "trivium" or "quadrivium."

2. Science teaching requires a duality of knowledge and ability. The science teacher has two jobs on his hands; he has to have a mastery of the technique of the laboratory as well as the usual knowledge of the subject matter and pedagogy of that subject.

3. The pedagogy of science has not reached an equilibrium. Some thought is now being turned in this direction.

4. The average science teacher is too narrow.

5. The science teacher as a rule has had little or no research.

6. Science teaching has been divorced from daily life. Fortunately the trend is now headed the other way.

Taking up the first point, it is a matter of observation that in all things human the wasteful but inevitable "trial and error" method has been the one by which ultimate perfection, or at least something approaching an efficient standard, has been attained. This is true in the case of high school science teaching which is less than a quarter of a century old. Also, it must be borne in mind that new discoveries in the industrial and scientific world often necessitate the abandonment of apparatus, texts and even method soon after adoption. A text-book in high school physics or chemistry that is ten years old is ancient history; one written a quarter of a century ago belongs to the stone age. The older subjects such as the languages or mathematics have had the benefit of the trial and error method and represent the product of an evolution—the "survival of the fittest" in method. What is left is indeed good and I am one of those who believe that Latin is a necessary preparation for scientific study, if for no other reason than its value in assisting in scientific nomenclature. I also believe that mathematical problems should deal with problems of physics or chemistry or biology rather than with finance and business. I seriously resent the implication manifest in some quarters that the business man or banker is the ideal of success and that the school is preparing solely for such a life. The value of good English training especially along the line of clear and vigorous expression, oral and written, stressing the Anglo-Saxon foundation, is inestimable, especially where themes on scientific subjects are occasionally assigned.

Cooperation between English teacher and science teacher is entirely feasible and eminently desirable. The English teacher may correct the English of the scientific theme while the same theme may be turned over to the science teacher for correction of ideas in line with the particular science involved.

Under point 2, it is a well known fact that very often the highest type of theorist is deficient in the ability to handle material equipment, in skill. This implies no adverse criticism of his mental ability or value, but is a serious handicap. One who, on the other hand, is deft, is often found drawing a good salary under the aegis of his trade union. Those who are "motor-minded" are usually motor-employed.

In regard to point 3, it is true that recently some good books on the pedagogy of science teaching have appeared. Two that I have in mind at present are Hodson's *Broad Lines in Science Teaching* and Twiss's *Science Teaching.*

In regard to point 4, it may be stated that professional men in general are apt to specialize along one particular line and get into a rut, preferring the "easy way" of going over the same old stuff without going to the trouble of trying to revivify it. Certain formulae and phrases, indeed, even certain viewpoints have become fixed in the method of teaching of certain teachers. It must be remembered that to a great extent the interior of the school is withdrawn from the main current of life and that all we teachers get is some of that which filters in from the outside world. The fight to keep abreast of events is an uphill fight for us all at best, but more especially is this true in the case of the science teacher. In order to lend zest to my general science classes, I have offered a small prize for the best note-book of current items of scientific interest clipped from the newspapers. These items are dated with the name of the paper and a note is made as to whether the item pertains chiefly to astronomy, physics, chemistry, geology, etc. Any device that gets away, by any ruse, from the conventional or stereotyped method of procedure is of value. That is where originality counts.

Research is an absolute necessity if the teacher is to be anything more than an intellectual parrot, taking the ideas and methods of others and attempting to apply them without any understanding of the genetic bases of at least one of the sciences. It does not make any especial difference what science he is teaching or what particular science he has done research in; the important fact is that he must have learned to stand on his own feet and if an earthquake should come he should be able to reconstruct his science and his methods from the bottom up. It is pitiful to see inadequately trained teachers waste hours of time in institutes discussing certain "methods" of certain teachers. Teaching is an art and of all things, the teacher must be adaptable. It calls for an unusual type of man or woman.

Under point 6, I can well refer to Oswald Latter,[2] who, speaking of biology teaching, says: "In any case it is the common everyday animal and plant that should receive the closest study. Worms, snails, oysters, or mussels, insects of many kinds, fish, frogs and toads are not difficult to procure nor *to study alive* at any inland school.

"A really valuable and much needed bit of work consists in the study of the germination and early stages of common weeds. Sets of pupils might be assigned to look after about half a dozen species each, to keep records of their behavior and make sketches and photographs at frequent intervals. Each task may be considered complete when seed has been obtained from the plant which developed from the seed sown."

In his discussion of high school physics, Alfred W. Porter[3] takes pains to protest against the tendency in some quarters to give an almost entirely mathematical cast to that subject. The main idea is to illustrate the physical laws at work in a qualitative sense rather than a quantitative sense. Mathematics must be brought in but they must be subordinated to the main emphasis of the science. It is time enough in college to bear down hard on the mathematical end. "There is a kind of tuition in physics which everyone should have, and which I alluded to as an 'informal introduction.' Others have written about allowing boys to play with magnets and cells. Let them make glass-rubbed electric machines and Leyden jars out of bottles bought cheaply from the grocers. Never mind whether or not you can reduce these things to mathematics; perhaps do not even try to do so at an early stage. The interest that can be aroused by this scientific play, the familiarity with things that is gained, are all to the good in connection with later teaching."

Dr. Henry Garrett, in treating the matter of chemistry teaching[4] says: "In the secondary school the object is not so much to teach chemistry as to use the subject for the cultivation of observation, reasoning power, and systematic habits. The aim is distinct from that of the university and the method employed is different."

In conclusion, let me say that the cyclic pawing-over of the same ground, year in and year out, without enlarging one's mental and spiritual horizons, without the zest that comes from a comprehension of new truth, modifications of old truths, without *new view points*, cannot make science teaching in the high school anything but a dry skeleton whose bones rattle in the winds of modernism. Big men and women are needed—men and women who are interested in humanity, in individuals, in boys and girls, who have some knowledge of the findings of the allied sciences such as sociology, psychology and ethnology.

[1]*Reorganization of Science in Secondary Schools*, A Report of the Commission on the Reorganization of Secondary Education, Appointed by the National Educational Association (1920). U. S. Bureau of Education, Bulletin 26.

[3,4]*Broad Lines in Science Teaching*, edited by F. Hodson, Ph. D. (English), Macmillan. 1910

PROBLEM DEPARTMENT.

CONDUCTED BY J. A. NYBERG,
Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1039 E. Marquette Road, Chicago.

LATE SOLUTIONS.

712. *D. L. MacKay, Bay Ridge H. S., Brooklyn, N. Y.*
720. *Lawrence Sellstrom, White Pine Co. H. S., Ely, Nevada.*
716, 722, 723. *L. R. Kellam, Culver Military Academy, Culver, Ind.*

SOLUTION OF PROBLEMS.

726. *Proposed by F. A. Cadwell, St. Paul, Minnesota.*

Three lines drawn from the vertices of a triangle ABC meet at a point O, either within or outside the triangle; AO, BO, and CO intersect BC, AC, and AB respectively at H, F, and G. A perpendicular drawn from H to FG meets FG at I. Prove (1) HI bisects $\angle$BIC, if F and G are points on AC and AB unproduced, or if on AC and AB produced; (2) FI bisects $\angle$BIC if F is on AC unproduced while G is a point on AB produced.

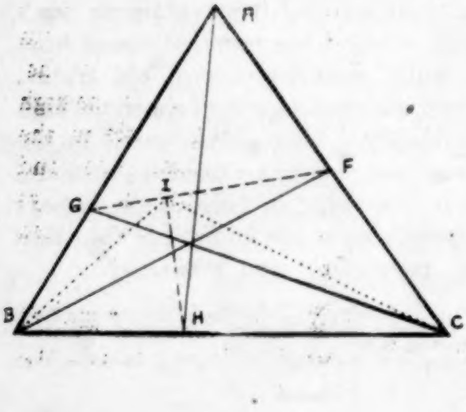
Solution by Nelson L. Roray, Netuchen, N. J.

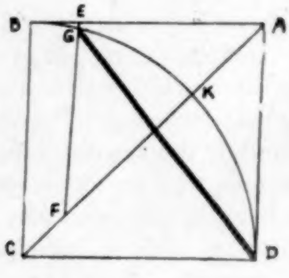
Case I. When the points are on the sides unproduced.
In $\triangle$BIH, sinBIH/sinBHI = BH/BI. In $\triangle$HIC, sinHIC/sinIHC = HC/IC.
Since $\angle$BHI + $\angle$IHC = 180°, sin BIH/sin HIC = BH/HC . IC/IB. Also sinFIC/sinIFC = FC/IC; sinAFG/sinAGF = AG/AF; and sinBGI/sinGIB = BI/BG. The product of the last four equations is sinFIC $\times$ sinBIH/sinGIB $\times$ sinHIC = FC $\times$ AG $\times$ BH/FA $\times$ GB $\times$ HC = 1. (Ceva's Theorem. See Problem 677). Hence cosHIC/sinHIC $\times$ sinBIH/cosBIH = 1 or tanBIH = tanHIC, and so $\angle$BIC is bisected.

When the points F and G are on the sides produced, the same method of proof applies; in this case we deal with sines of equal angles instead of supplementary angles.

Case II. When G is on AB produced, and F on AC unproduced. The same method applies and we use the relations $\sin(90 \pm \theta) = \cos\theta$.

Also solved by *J. F. Howard, San Antonio, Texas,* and the *Proposer.* If trigonometry is not used in the proof, essentially the same relations must be derived from similar triangles. The trigonometry furnishes a convenient notation and derivation of the necessary equations.





727. *Proposed by Elmer Schuyler, Bay Ridge H. S., Brooklyn.*

The following is *Buonfalce's* method of approximating $\sqrt[3]{2}$. Find how close an approximation it is.

Construct a unit square ABCD on the line AB. With C as a center and CB as a radius draw the quadrant BD intersecting the diagonal AC in K. From B towards A, lay off BE = AK/2; and on CA lay off CF = BC/4. Join F to E, cutting the arc in point G. Then DG is approximately $\sqrt[3]{2}$.

Solution by Walter C. Ells, Whitman College, Walla Walla, Wash.

Taking C as the origin, the coordinates of E are $(\sqrt{2}-1)/2$, I and of F are $\sqrt{8}/2$, $\sqrt{8}/2$. Hence the equation of the line EF is $2y=(20\sqrt{2}+26)x-(5+3\sqrt{2})$. Solving this simultaneously with the equation of the circle $x^2+y^2=1$, we find the coordinates of the point G; viz.

$x=(125+89\sqrt{2}\pm[1437+1010\sqrt{2}]^{1/2}\div(740+520\sqrt{2})=.20631413$, and $y=.97848581$. Hence the length of GD $=[y^2+(1-x)^2=1.25990942$. Since the value of $\sqrt[3]{2}$ to 7 places is 1.2599210, the error is 1 part in 125,000 or 12 times as accurate as the construction given in problem 702.

Also solved by *E. Tabor, Upper Lake, Cal.*, and by the trigonometry class, *Brackenridge H. S., San Antonio, Tex.*

728. *Proposed by Norman Anning, Ann Arbor, Mich.*

Prove: If x to the power 2^2 is equal to 2 to the power x^2, then either is equal to $6x^2-8$.

Solution by E. Tabor, Upper Lake, California.

By inspection we see that $x=\pm 2$ is one possibility. And if we put $a=x^2$, then $a^2=2^a$., so that $a=2$, or $x=\pm\sqrt{2}$. Then $(x+2)(x-2)(x+\sqrt{2})(x-\sqrt{2})=0$ is an equation having the same root as the given one. Therefore $x^4-6x^2+8=0$ or $x^4=6x^2-8$. Also x^4 equals x to the power 2^2 or 2 to the power x^2.

Also solved by *Walter C. Ells, J. F. Howard*, and *Milton D. Oestreicher, Bucyrus, Kans.*

729. *Proposed by Arthur H. Lord, Lynn, Mass.*

Ten hours after a man had started on a trip a second man followed, gaining 3 miles every hour on the first. When he had been gone 8 hours, he met an expressman traveling at the same rate as he was, who said he had passed the first man 2 hours 24 minutes before. How long did it take the second man to overtake the first?

I. *Solution by Martha L. Rodman, Aledo, Illinois.*

Let x = rate of first traveler; then $x+3$ =rate of second.

When the expressman and the second traveler meet, the sum of their distances will equal the distance travelled by the first man in 15 3-5 hours, (18−2 2-5). Hence(8+2 2-5) $(x+3)=(18-2\ 2\text{-}5)x$ or $x=6$. The rates of the first and second traveler and 6 and 9.

Now let y =number of hours required for the second man, after meeting expressman, to overtake the first man. Then $9(8+y)=6(18+y)$ or $y=12$. Hence the second man overtook the first in 8+12 or 20 total hours.

The same method was used by *Moe Buchman, College of the City of New York; Wm. Campbell, Temple University, Philadelphia; Thomas E. N. Eaton, Redlands H. S., Cal., Henry L. Wood, Boonton, N. J.* The following solution by a high school pupil is well stated:

II. *Solution by Hazel Schwab, Torrington H. S., Wyoming.*

Let x =mileage per hour of first man.

Then $x+3$ =mileage per hour of second man.

$10x$ =the distance between 1st and 2nd when the 2nd starts, or the number of miles which the 2d man must gain.

$10x/3$ =time needed for 2d to overtake 1st.

$18x-8(x+3)$ =distance between 1st and 2d when the 2nd has been traveling 8 hrs.

$12x/5+12(x+3)/5$ = same distance figured from the statement of expressman.

$\therefore 18x-8(x+3)=12x/5+12(x+3)/5$ or $x=6$.

Then $10x/3=20$ hrs, time needed for 2d to catch 1st.

The same argument for deriving the equation was used by *Harold*

L. Bishop, Fred Gowland, Ysabel Hastings, pupils in the *Redlands High School*. The proportion $(x+3):x = 15\ 3\text{-}5:10\ 2\text{-}5$ was used by *J. F. Howard*, and by *Doella Douman, Margaret Dounan, Andrew Strang, Reva Rose, Redlands H. S.* Other solutions by *Michael Goldberg, Philadelphia; Irma Luelleman, Mattoon, Ill.; Milton D. Oestreicher, Bucyrus, Kans.; H. Ruzicki, St. Martin's College, Lacey, Wash.; E. Tabor, Upper Lake, Cal.; A. J. Wile, Kanai H. S., Kanai, Hawaii; Harlan Beem and Ruth Preston, pupils, Mattoon, Ill.; Phillips Finlay, Redlands.*

730. *For high school students. Proposed by the Editor.*

If AD is the altitude and AE the bisector of the $\angle BAC$ of the $\triangle BAC$, prove $\angle DAE = (\angle B - \angle C)/2$.

The object is not merely to find *a* proof but a *good* proof; and not merely to find a *proof* but also to have a good *presentation.*

I. *Proof by Chester Frisbey, North East H. S., Kansas City, Mo.*

Draw MN || BC forming angles 1 and 2.

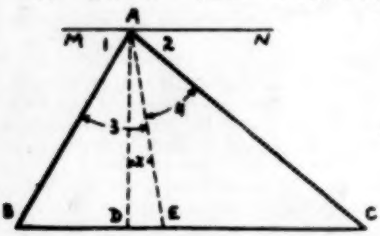
(1)	$\angle B = \angle 1$.	Two parallel lines cut by a transversal, the alternate interior angles are equal.
(2)	$\angle C = \angle 2$.	Same as (1).
(3)	$\angle 3 = \angle 4$.	AE is the bisector of $\angle BAC$ forming angles 3 and 4.
(4)	$\angle 1 + \angle 3 - \angle x = 90°$	AD, the altitude, is $\perp$ BC and MN.
(5)	$\angle 2 + \angle 4 + \angle x = 90°$.	Same as (4).

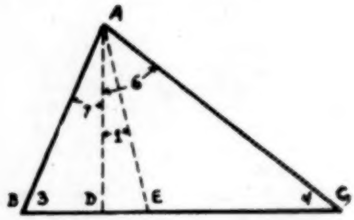
(6) By eliminating and adding in (4) and (5), angles 3 and 4 being equal

$\angle 1 - \angle 2 - 2\angle x = 0$.

$2\angle x = \angle 1 - \angle 2$.

(7) $\angle DAE = (\angle B - \angle C)/2$ Equals may be substituted for equals.





II. *Proof by Ben Shaw, Salida, Colorado.*

In the rt $\triangle$S DAB, DAC.

$\angle 3 + \angle 7 = \angle 4 + \angle 6$	The sum of the $\angle$s of a $\triangle = 180°$.
$\therefore \angle 3 - \angle 4 = \angle 6 - \angle 7$.	Transposing.
$\angle 7 + \angle 1 = \angle 6 - \angle 1$.	Given $\angle EAB = \angle EAC$.
$\angle 1 + \angle 1 = \angle 6 - \angle 7$.	Transposing
$\therefore 2\angle 1 = \angle 6 - \angle 7$.	Add $\angle 1 + \angle 1$.
$\therefore 2\angle 1 = \angle 3 - \angle 4$.	A quantity may be substituted for its equal in an equation or in an inequality.
$\therefore \angle 1 = \frac{1}{2}(\angle 3 - \angle 4)$	If equals are subtracted from equals the remainders are equal.

The three next best proofs were by *Owen Lincoln, Newark, New York; Hazel Schwab, Torrington, Wyo.; Romola Reese, Mattoon, Ill.* Also proved by *Vernon Bigsby; Aledo, Ill.; Ernest M. Clays, Ely, Nevada; Harold Cohen, Kansas City, Mo.; Grace Hooser, Torrington, Wyo.; Clarence Knous, Ely, Nevada; Richard Lewis, Kansas City, Mo.; George Maishaider, Mattoon, Ill.; Ward McMasters, Mattoon, Ill.; Theodore J. Moser, Boonton, N. J.; Luella Sage, Salida, Colo.; Erich Sobota, Kansas City, Mo.; Nevada Tabor, Upper Lake, Cal.; Geo. S. Walker, Mattoon, Ill.; Buella Wilson, Kansas City, Mo.*

PROBLEMS FOR SOLUTION.

741. *Proposed by Harris F. MacNeish, College of the City of New York.*

Find without using trigonometry the volume of a regular icosahedron in terms of the edge e.

742. *Proposed by Walter E. Warne, Pennsylvania State College, State College, Pennsylvania.*

Equilateral triangles BCD and BCD′ are drawn on the side BC of a triangle ABC. Prove $(AD)^2+(AD')^2 = a^2+b^2+c^2$.

743. *Proposed by Daniel Kreth, Wellman, Iowa.*

Show that $1+x^4$ is never less than x^3+2x^2.

744. *Proposed by Elmer Schuyler, Bay Ridge High School, Brooklyn.*

ABCD is a concyclic quadrilateral, where A, B, C, D are taken in order. AB and DC intersect in Q; DA and CB in P. The bisector of $\angle$P meets AB in R and CD in T. The bisector of $\angle$Q meets BC in S and DA in W. Prove that the figure formed by joining R, S, T, W in succession is a rhombus.

745. *For high school students. Proposed by the Editor.*

A farmer wishes to cut half of a rectangular field of grain by cutting a strip of uniform width around the field. His rule for finding the width of the strip is: from the sum of the length and width subtract the diagonal, and divide the result by 4. Prove the correctness of the rule

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A SCIENTIFIC MARKING SYSTEM.

Los Angeles, Cal., City Schools.

1. What do marks measure? There is little agreement among educators and teachers as to the trait or traits which marks measure. However, all of the qualities suggested can be roughly classified under three heads: (1) Capacity, (2) Ability, and (3) Performance. Courtis has defined these as follows:

Capacity is potential ability—it is the mentality furnished by nature and is beyond the control of education. It is the result of heredity.

Ability is the "general power to do." It is the result of the action of maturity, general experience and directed training on the individual nature of the child.

Performance is "specific achievement"—what an individual is able to do under given conditions. It is the specific product of ability. Manifestly, ability can only be measured through performance which is its objective manifestation—thus performance becomes a basis of inference as to ability.

There are two rather striking things concerning performance which have been noted by investigators and which should be taken account of by administrators in formulating and administering marking systems. An individual's performance on any single test is highly variable. This is noted again and again in measurement work. An individual's score will be low one day and high the next without any apparent reason for the change. On the other hand, the average of a series of scores is relatively stable. This is borne out by all of the investigations with tests.

Which of these three qualities, then, do marks measure? In as much as capacity, the "start in life" which nature gives, is wholly beyond the control of the pupil or teacher and is neither increased or decreased by training, it is obvious that school marks do not measure this quality. Ability is the power to do—the result achieved by the action of training on native capacity. Training is the primary work of the school and naturally the product of this training is the thing which marks should measure. But ability cannot be measured, it can only be "inferred" from specific performance. By taking an average of a number of performances (three or more), ability can be determined and proper marks assigned.

Many teachers maintain that such qualities as "energy," "industry," "effort," "attitude," etc., should be considered in the assignment of marks.

As a matter of fact "specific performance" is the result of the interplay of all of these factors and each of these qualities may be assumed to be properly cared for when performance is made the basis of school marks.

2. Theoretical distribution: Practically all authorities on the subject of school marks agree that they should distribute on the normal probability curve. Experiments have shown that all biologic data are so distributed. All of the experiments on mental functions and the results from mental tests seem to indicate that intelligence likewise distributes normally. This satisfies the theory that native capacity is the result of a chance event—the resultant of an infinitely large number of causes, equal in effect and equally often operative. The normal curve is the curve of the chance event.

Some of the earlier writers favored skewed distributions on the ground that students are a selected group and contain more than an average number of those who are above the average in intelligence. Present day writers are agreed that such skewness is not warranted and the normal distribution is favored.

3. Divisions and symbols: There is practically unanimous agreement that a marking system should have *five* divisions. This seems to be the number which can best be differentiated by the human intelligence. This gives the Medium, the Superior and Inferior, the Excellent and the Poor. Fewer divisions do not give proper balance. Three divisions are not enough and four divisions do not fit the normal curve. It is almost impossible to comprehend more than five divisions and hold them constantly in mind.

The scale adopted by the War Department for rating Army officers has five divisions. Walter Dill Scott's scale for rating employes has the same number. Rugg, in adapting the Army scale to the rating of teachers, retained the five division feature.

In the matter of symbols, the letters A, B, C, D, and E are the most commonly used. There is a tendency to get away from the percentile system as much as possible. Such a scale has such small intervals that no human intelligence can discriminate between them. Yet there are teachers who give such grades as 79 5-8. Such a practice is absurd! The writer would advocate the use of the letter symbols mentioned above without reference to their percentile value. If the percentile system must be kept by some people, they should at least use only numbers as can be clearly discriminated—95, 90, 85, 80, etc.—never closer than five points. Furthermore, if the percentile system is used, the whole range should be employed from 0 to 100, instead of the upper 20% or 30%.

The writer would propose the following as a sound and scientific marking system so far as distribution, divisions, and symbols are concerned:

A	B	C	D	E
Exc.	Sup.	Med.	Inf.	Poor
7	24	38	24	7

These percentages are obtained by cutting the baseline of the normal curve at 2.5 sigma and -2.5 sigma and dividing this baseline into five equal parts, each one sigma long. Referring to the probability tables of the normal curve, we find that the areas inclosed between these equal increments of the baseline and the curve are 7%, 24%, 38%, 24%, and 7%.

4. Use of the rank method: Another helpful method of making marks more objective is the "measurement by relative rank" method suggested by Cattell in 1905. Before marks are assigned to a class, the members should be arranged in order of rank. This makes the placing of the individual in the group relatively easy for the instructor. After the rank

list is made, marks should be distributed according to the system outlined above.

5. Determining difficulty of problems: Another device which can be effectively used in objectifying teachers' marks is the use of the normal curve in determining the relative difficulty of a series of questions or problems. Seldom are two questions of equal difficulty, yet it is practically impossible for a teacher to properly weigh them without some objective standard.

A common way is to determine the percentage of the class which fails on each problem. By consulting a scale of merit table the value of a problem can be found which is failed by any percentage of the class. In this way the problems may be weighted according to the difficulty which they give to those who are to be marked.

The "Scale of Merit" table is constructed by superimposing a percentile baseline on the baseline of the normal curve (it is best to cut the curve at 2.5 sigma), and determining the area of the curve above each per cent of the percentile scale. This gives a table showing the "Scale of Merit" for problems of varying difficulty as evidenced by the number of students failing them. The following shows the nature of such a table:

Per Cent Wrong:	*Sigma Distance:*	*Merit:*
1%	−2.33	3
2%	−2.05	9
3%	−1.88	12
4%	−1.75	15

6. Determination of standards: Perhaps the greatest need in teachers' marks today is the formulation of definite standards for each mark. A mark should be clearly defined so the teacher, the pupil and the parent will know exactly what it means. An "A" should be more than a mere letter or symbol; it should stand for definite accomplishment of a definite amount of work with a definite quality of workmanship.

A number of attempts have been made recently to so define school marks. W. A. Bailey, in 1917, described a scheme of definition which he had worked out.* While it is it by no means perfect, it is a suggestive beginning.

7. Program for improving marks: The following suggestions for improving teachers' marks have been gathered from the different writers on the subject:

1. Periodic publication of teachers' marks.
2. Discussion of these marks in teachers' meetings.
3. Require teachers to tabulate and plot marks.
4. Require teachers to "rank" pupils before marking.
5. Definitions of exact requirements for each mark.
6. Require reading and discussion of marking systems.
7. Use of objective scales and tests.
8. Use of mental tests for classification.
9. Letter symbols should be related to word-statements.
10. Use five divisions on scale—if per cent must be used avoid steps of less than five points.

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Members of the Illinois Section of the Mathematical Association of America:

As directed at your last meeting in Chicago, we are arranging for a meeting of the Illinois Section in connection with the meeting of the Illinois State Academy of Science at Rockford, Ill., on April 28 and 29. We are hoping that the program, given below, will prove attractive enough to make you plan at once to attend one or all of the sessions. The value of the opportunities such a meeting offers during the social hours between sessions to meet and exchange experiences with those engaged in similar work and facing similar problems should not be forgotten. A complete Academy program will be mailed to you later, with an opportunity to sign up for the dinner Friday evening.

C. E. Comstock,
E. J. Moulton,
E. B. Lytle,
Program Committee.

March 11, 1922.

Program

Friday, 2 P. M.

1. Constructive Methods in Geometry. Prof. Emch, University of Illinois.
2. Some Aspects of Correlation Theory. Mr. Mensenkamp, Freeport High School.
3. Romance in Science—An Experimental Course Offered by a Mathematics Department. Prof. Bessie Miller, Rockford College.
4. Consistency in Grading Mathematics Papers. Prof. E. J. Moulton, Northwestern University.

Friday Night.

5. An illustrated lecture on "Cosmogony" by Prof. MacMillan of the University of Chicago before a joint meeting of the Illinois Section and the State Academy of Science.

Saturday, 9 A. M.

6. The National Committee Report on College Entrance Requirements in Mathematics (published in the Mathematics Teacher for May, 1921). Discussion led by Prof. Wahlin, University of Illinois, Dr. Kinney, Crane Junior College and Prof. Parson, DeKalb State Teachers College.
7. How Many and What Mathematics Courses Should be Offered to College Freshmen? Discussion led by Prof. Scott, Illinois College and Prof, Ginnings, Macomb State Teachers College.

April Meeting of the Illinois State Academy of Science

THE next meeting of the Illinois State Academy of Science is to be held at Rockford College, ROCKFORD, APRIL 27-29.

The tentative program that is in preparation provides for— Thursday afternoon, business meeting, general session. Thursday evening, general session, two addresses, one of which is the address of the retiring President. Friday forenoon, general session, address, followed by a symposium on the "Structure of the Atom." The atom of the physicist as well as that of the chemist will be discussed in a manner so as to be equally intelligible to the geologist, biologist or mathematician. Friday afternoon, sectional meetings. Academy banquet at six o'clock at Rockford College. Friday evening, general session, address by Professor MacMillan of the department of astronomy, University of Chicago, on "Cosmogony." Saturday, field trips to interesting points near Rockford, the Chamber of Commerce of Rockford and Rockford College as hosts. Plan to attend the entire program.

The program committee is pleased to announce that the Illinois Branch of the Mathematical Association of America will meet in affiliation with the Academy all day Friday, and Saturday morning.

Those desiring to present papers before the various sections of the Academy should send titles direct to Secretary C. Frank Phipps, State Teachers College, DeKalb, Ill. The program will be mailed on April 15.

The program committee is desirous of bringing the activities of the Academy to the attention of as large a number of scientists as possible. To this end may we not have your cooperation? Please call the attention of fellow scientists to our State Academy, its purposes, scope, and accomplishments. The new arrangement of our affiliation with the American Association for the Advancement of Science, whereby one may become a member of both for the price of the latter, is particularly attractive. More than 100 Illinois scientists took advantage of this combination offer last year. Those interested should address the chairman of the Membership Committee, Professor C. F. Hottes, University of Illinois, Urbana, Ill., who will gladly forward the necessary blanks.

It is expected that a number of scientists from the Wisconsin Academy of Science and the Beloit Science Club will be present.

Dr. C. T. Knipp, Chairman,
H. C. Cowles,
C. F. Phipps,
Program Committee.

SIX HUNDRED COURSES OFFERED AT THE UNIVERSITY OF CHICAGO FOR THE SUMMER QUARTER.

More than six hundred courses are to be offered at the University of Chicago for the summer quarter beginning June 19 and ending September 1. They will include those in Arts, Literature, Science, Divinity Law, Medicine, Education, Commerce and Administration, and Social Service Administration. The first term will begin June 19 and the second term July 27, and students may register for either term or for both. The last summer quarter attendance was the largest in the history of the University—6,458.

THE REORGANIZATION OF MATHEMATICS IN SECONDARY EDUCATION.

The Final Report of the National Committee on Mathematical Requirements is to be distributed free of charge to all interested in securing a copy.

The complete report of the National Committee on Mathematical Requirements is in the press and will, it is hoped, be ready for distribution in April. It is published under the title "The Reorganization of Mathematics in Secondary Education," and will constitute a volume of about 500 pages. The table of contents given below indicates its general character.

Through the generosity of the General Education Board the National Committee is in a position to distribute large numbers of this report free of charge. It is hoped that the funds available will be sufficient to place a copy of this report in every regularly maintained high school library and also to furnish every individual with a copy free of charge who is sufficiently interested to ask for it. Requests from individuals for this report are now being received. They should be sent to J. W. Young, Chairman, Hanover, New Hampshire. Individuals interested in securing a copy of this report are urged to send in their requests as early as possible. If the number of requests received exceeds the number the committee is able to distribute, the earlier requests will receive the preference.

The table of contents of the report is as follows:

Part I. General Principles and Recommendations:

Chapter I A Brief Outline of the Report.

Chapter II Aims of Mathematical Instruction—General Principles.

Chapter III Mathematics for Years Seven, Eight and Nine.

Chapter IV Mathematics for Years Ten, Eleven and Twelve.

Chapter V College Entrance Requirements.

Chapter VI Lists of Propositions in Plane and Solid Geometry.

Chapter VII The Function Concept in Secondary School Mathematics.

Chapter VIII Terms and Symbols in Elementary Mathematics.

Part II. Investigations Conducted for the Committee:

Chapter IX The Present Status of Disciplinary Values in Education, by Vevia Blair.

Chapter X The Theory of Correlation Applied to School Grades, by A. R. Crathorne.

Chapter XI Mathematical Curricula in Foreign Countries, by J. C. Brown.

Chapter XII Experimental Courses in Mathematics, by Raleigh Schorling.

Chapter XIII Standardized Tests in Mathematics for Secondary Schools, by C. B. Upton.

Chapter XIV The Training of Teachers of Mathematics, by R. C. Archibald.

Chapter XV Certain Questionnaire Investigations.

Chapter XVI Bibliography on the Teaching of Mathematics, by D. E. Smith and J. A. Foberg.

WATER POWER OF THE WORLD.

Forty per cent of the developed water power of the world is in the United States, where water wheels having a capacity of 9,243,000 horsepower have been installed, according to a recent statement of the United States Geological Survey, Department of the Interior. The leading States in developed water power are New York, with 1,300,000 horsepower, and California, with 1,111,000. These state totals compare favorably with those for some of the most progressive countries in water power development in Europe, where France leads with 1,400,000 horsepower. Norway has 1,350,000 horsepower, Sweden 1,200,000 horsepower, and Switzerland 1,070,000 horsepower. The largest percentage of power has been developed in the New England States, where the capacity of the water wheels installed is 1,381,000 horsepower and the estimated potential power at low water without storage is 868,000 horsepower. In the Pacific Coast States—Washington, Oregon, and California—the capacity of water wheels installed is 1,893,000 horsepower and the potential power at low water without storage is 11,500,000 horsepower. The largest water-power development in the world is at Niagara Falls, where the plants in operation have a capacity of 870,000 horsepower, of which 385,500 horsepower is on the United States side. The capacity of the plants at Niagara is being increased by 114,500 horsepower in the United States and 300,000 horsepower in Canada. Other large plants are one of 170,000 horsepower on the Mississippi at Keokuk, Iowa, from which power is transmitted to St. Louis, and two plants aggregating 268,500 horsepower on St. Maurice River in Canada, from which power is transmitted to Montreal, Quebec, and other cities. Canada ranks next to the United States in water-power development, with 2,418,000 horsepower, or over 10 per cent of the world's total.

Europe has one-third of the developed water power in the world. Two plants at Rjukan, in Norway, have a total capacity of 239,000 horsepower and at Trollhattan Falls the Swedish Government has installed a plant of 155,000 horsepower. At Lake Fully, in Switzerland, the remarkably high head of 5,413 feet is utilized. France, Italy, Germany, Norway, Sweden, and Switzerland have each developed more than 1,000,000 horsepower.

In Asia, Japan, with 1,000,000 horsepower, and India, with only 150,000 horsepower, are the foremost countries in water-power development.

New Zealand has developed only 45,000 horsepower but it rapidly increasing this amount. Australia has practically no developed water power. The island of Java has 56,000 horsepower developed or to be developed by plants under construction. Africa possesses only 11,000 horsepower of developed water power.

The total potential water power of the world is estimated at 439 million horsepower at low water, of which 62 million horsepower is in North America and 28 million in the United States. Africa is richest in undeveloped water power, with 190 million horsepower; Asia has 71 million horsepower, South America 54 million horsepower, and Europe 45 million horsepower.

The World Atlas of Commercial Geology, Part II, Water Power of the World, which has just been published by the United States Geological Survey, summarizes all present knowledge of that subject, mentions briefly some of the world's largest water-power developments, and gives estimates by countries and by continents of the developed and undeveloped water power. It includes 37 pages of text and 10 maps and is sold for $1 a copy.

SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION WINTER MEETING.

The Southern California Science and Mathematics Association is growing rapidly. This was most apparent at the annual winter meeting when several hundred members and friends from southern California high schools, private schools, and colleges, listened to a splendid program and took part in the lively discussions at both the general meeting and the section meetings that followed it.

Minutes

The annual regular meeting of the Association was called to order in Central Junior High School at 1:30 p. m., December 22, 1921.

Dr. J. E. Bell of California Institute of Technology introduced the speaker, Dean C. H. Benjamin, formerly of the School of Engineering of Purdue University, who spoke on "Educational Vaudeville." The speaker decried some of the modern tendencies to dress up various subjects in the curriculum to make them appear easy and artificially attracttive, instead of insisting upon good old-fashioned hard work to get results. The address was very well received and heartily applauded.

The business session of the Association immediately followed the address, the minutes of the preceding meeting on April 9, 1921, and of the Executive Committee meeting on October 1, 1921, being read and accepted

The Secretary-Treasurer's financial report was next read and, after being audited by J. S. Goldthwaite and Miss Laura E. Liddle, was accepted.

New business being next called for, adoption of the resolution appended hereto was moved by Dr. Lowell C. Frost of Franklin High School, Los Angeles. It was seconded, and after some discussion was carried, thus providing that the Association appoint a committee of three to examine into all films now available and suitable for educational use and cooperate in visual education by furnishing information on these subjects to those desiring it. (Committee: Dr. L. C. Frost, Franklin High, Miss A. O. Stoddard, Pasadena High, Mr. R. C. Van Cleve, Los Angeles High.)

Mr. C. W. Gray, of Hollywood High School, introduced the subject of getting on to the Teachers' Institute program next year some speakers on subjects of particular interest to this Association, with section meetings for the various groups of mathematics and science subjects. Miss Willson, of Manual Arts, Mr. Goldthwaite, of Lincoln High School, and Mr. Culbertson, of Pasadena High School spoke along the same lines. It was finally moved, seconded, and carried, that the President appoint a committee of three to interview the Program Committee of the Teachers' Institute next year and see to getting some science speakers on the program.

(Committee: Mr. C. W. Sandifur, Hollywood High; Mr. S. A. Skinner, Redlands High; Mr. H. M. Hills, Pomona High.)

A challenge to a membership campaign from C. A. Wheeler of the Modern Language Association of Southern California was next read. Mr. Newlin of Pasadena High School moved that the Association enter the contest and that a representative be appointed as suggested. Motion carried. (See challenge appended hereto.)

A communication from the Southwestern Museum was next read, asking that a committee be appointed to meet with Mrs. Frances Headlee, of the Museum to discuss possible cooperation between it and the science departments of the high schools. Mr. Gray moved that this be done and the motion was seconded and carried. (Mr. Knupp appointed on

this committee Miss Murphey, of Lincoln High School, and Miss Webber, of Hollywood High School.)

The proposed amendment to the constitution was next read, substituting for the phrase "the Past Presidents of the Association" the phrase "the officers of the Association for the preceding year" in section 3, part (d) of the fourth article in the constitution, regarding officers. Miss Sanborn moved the adoption of this amendment and the motion was duly seconded and carried by more than the necessary two-thirds vote of the members present, thus being legally adopted according to Article 9 of the constitution.

The report of the nominating committee for officers for 1922 was next called for and the following names were presented: President, M. L. Fluckey, of Lincoln High School; Vice-President, L. E. Wear, of California Institute of Technology; Secretary-Treasurer, Grace M. R. Abbot of Venice High School.

The motion to adopt this report was carried unanimously and the new officers were introduced to the Association.

There being no further business the meeting adjourned.

B. W. Howard,
Secretary-Treasurer.

Resolution on Advancement of Visual Education.

Whereas, Visual education by means of educational films has been made a vital part of the teaching of biology and other sciences in many of the foremost high school systems of this country, and has been found greatly to increase the efficiency of such teaching, and

Whereas, We believe that the high schools of southern California should be constructively progressive in the adoption of such methods of visual education as have been proven essential to the highest efficiency in teaching; therefore be it

Resolved, That the Southern California Science and Mathematics Association express its affirmation of the above premises, and its desire to cooperate in suing and developing visual education in the teaching of the science in the schools of its members. And

Resolved, That the Association direct its President to appoint a committee of three who shall, without incurring expense, prepare data regarding availability and relative merits of films on the market for the benefit of those wishing to use them, and who shall confer and cooperate with educational authorities for the furtherance of visual instruction.

A Friendly Challenge to
The Departmental Associations of Southern California:
Dear Friends:

At a meeting this afternoon of the Membership Committee of the Modern Language Association of Southern California a motion was carried to the following effect:

1. That all the Departmental Associations in Southern California connected with the Institute Program be asked to enter a membership contest for the year 1922 (or school year 1921-1922, if constitution so provides), under the following conditions:

(a) That for the purposes of this contest only teachers of the given subject or subjects in the Junior High School, Senior High School, College, or University be considered eligible.

(b) That the *percentage of actual members to eligible members* be the deciding percentage of the contest.

(c) That only members paying the current dues be considered members

(d) That the organizations entering the contest report their total

eligible membership and their actual membership on December 1, 1922.

(e) That the winning organization receive $5.00 from each of the other organizations competing.

(f) That each organization entering this contest appoint at its business meeting this December one of its members to serve on a Joint Membership Committee, said Committee to have power to make any further rules or arrangements necessary for the carrying out of the contest.

2. That each organization eligible to join this contest be asked to consider this proposal at its current business meeting and report at once any action taken to the Secretary of the Membership Committee of the M. L. A. S. C.

In pursuance of the above motion I am sending this invitation to each of the Associations listed in the program of the C. T. A.-S. S. which covers a field to which the proposed contest applies.

Two return postcards are enclosed: One is for the acknowledgment of receipt of this notice and statement as to whether its contests will be brought to the attention of the Association in question; the other is for notifying us of the action taken at the meeting, including name of committee member, if one is appointed.

Trusting that this proposal for strengthening the membership of all our organizations will meet with your approval and support,

Very cordially yours,

Carleton A. Wheeler,
Secretary, Membership Committee.
Modern Language Association of Southern California.

Snappy section meetings followed the general meeting. Section officers were elected for the coming year. Good programs provided were greatly enjoyed.

Biology Section—Chairman, A. E. Ricksecker, Hollywood High School; Secretary, Eleanor B. Green, Glendale High School. Address by Dr. Henry Harrower of Glendale on "The Ductless Glands or Glands of Internal Secretions," a very interesting exposition of the special work of the different glands in metabolism and the therapeutic value of this knowledge in overcoming and preventing sub-normal functioning due to disease or other devitalizing influence.

Mathematics Section—Chairman, R. W. Detter, Hollywood High School; Secretary, Ada McClellan, Long Beach High School. Address by Dr. Arleigh C. Griffin on "Educational Measurements," Director High School Research, Los Angeles Schools, and address by Miss Mary Clark, of Pasadena High School, on "Some Tests in Geometry." Addresses excellent; attendance good.

Physics-Chemistry Section—Chairman, V. R. Ross, Covina High School; Secretary, C. W. Gray, Hollywood High School. Election of officers and general discussion. Very good attendance.

Earth Science Section—Met with Biology section. Officers to be elected at spring meeting. There is talk of changing the name of this section to General Science Section.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

Seventy-Fifth Meeting at the Massachusetts Institute of Technology.

The seventy-fifth meeting, on February 11, at the Massachusetts Institute of Technology was the most largely attended meeting ever held by the Association, over 140 being in attendance. In the morning Mr. F. S. Macalaster, official glassblower to the Physical Departments of

Harvard and Technology, demonstrated the making of bubblers, L-tubes, T-tubes, thistles, funnels and inner seals as well as the cutting and welding of glass. Professor William T. Bovie, of the Department of Biophysics of the Harvard Medical School, gave an illustrated address on "The Physical and Chemical Characteristics of Photoplasm." Professor Arthur A. Blanchard, of the Institute, spoke on the "New Requirements for Admission at Technology." A tour through the chemical laboratories of the Institute was followed by lunch at the Walker Memorial. At the afternoon session, held in the Arthur D. Little Laboratory, Dr. Littlee spoke on "Energy, Its Sources and Future Possibilities," and several teachers of chemistry gave a "Symposium on Teaching Experiments in Chemistry."

Industrial Excursion.

The January Industrial Excursion was to the Hygrade Lamp Company Salem, Mass. The making of gas-filled and vacuum lamps was seen and the process explained by officials of the company.

The Springfield Meeting.

The Third Regional Meeting of the Western Division of the Association was held at Springfield, Massachusetts, March 11, and included two trips, one to the Emerson Laboratory and one to the Springfield Gas Company. This meeting was arranged by a local committee consisting of Mr. Alfred R. Lincoln, Springfield Technical High School, Chairman; Mr. Frank Y. Hess, Central High School, Springfield; Mr. Donald B. Stevens, Springfield High School of Commerce, Mr. Dennis M. Cole, Westfield High School and Professor Arthur J. Hopkins, Amherst College. The afternoon meeting was held at the Technical High School. The regular committees of the Western Division gave reports, and plans for the continuance of regional activity were formulated.

The Seventy-Seventh Meeting.

A meeting will be held in Rhode Island the first Saturday in May under the auspices of the Executive Committee of the Southern Division. This meeting will be held either in Providence or at the Rhode Island State College. Further announcement will be made.

Reports of the Association Meetings Available.

Many requests have come to the secretary of the New England Association for reports of the meetings. These reports are full accounts of the proceedings, usually a 32-page pamphlet. They are printed for members only, not published for general sale. Teachers of chemistry outside of New England may secure these publications by joining the Association as associate members. The dues of $1.50 per year entitle members to all the publications issued, including a report of the proceedings of each meeting (usually six in number). Address further inquiries with reference to membership to the Secretary of the Association, S. Walter Hoyt, 20 Stone Road, Belmont, Massachusetts.

A GROWING CONCERN.

The Wiese Laboratory Furniture Company is a very lively and efficient manufacturing company in Manitowoc, Wisconsin. New officers of the corporation were recently elected. Over two thousand shares of stock were represented at this meeting. They have had a remarkable success since this firm was organized. A report from the salesmen present indicated that the company's capacity would be taxed to the utmost this coming year. They will probably do a business of five hundred thousand dollars during 1922. The salesmen indicate much success for this company during the present year.

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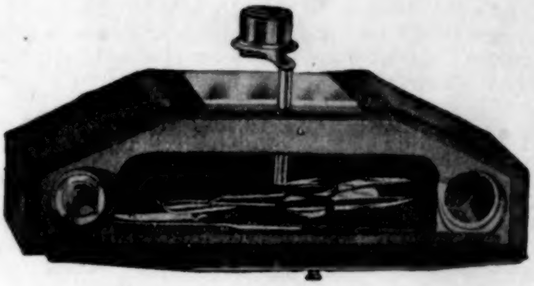

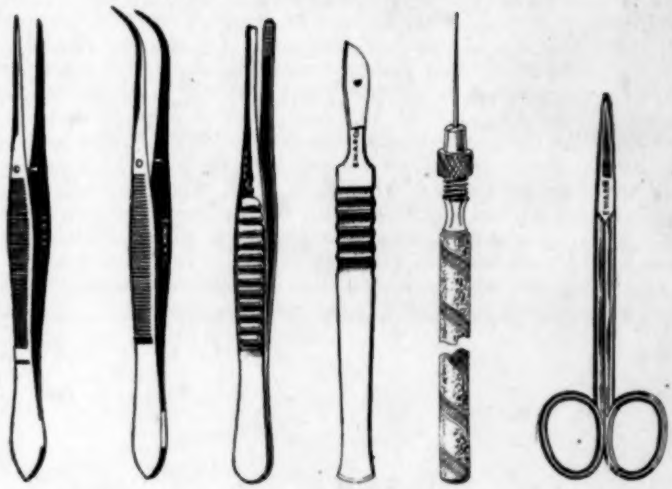

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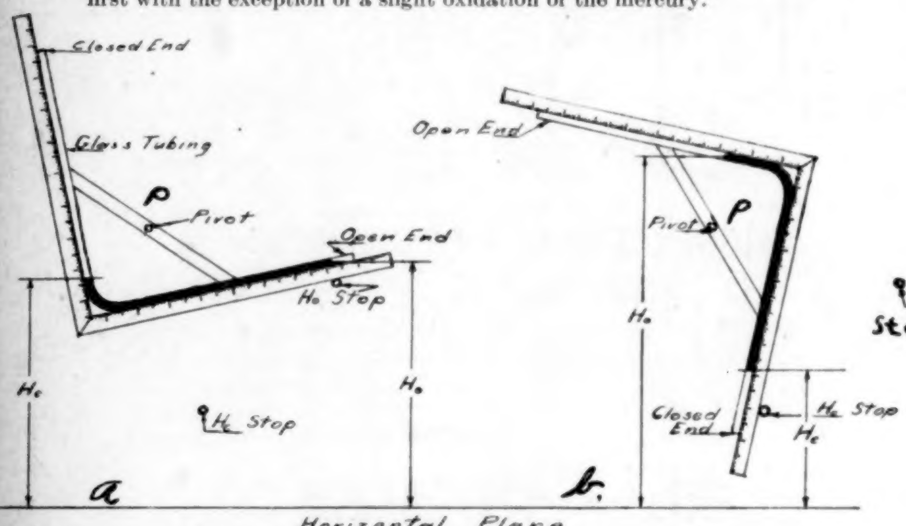
CHICAGO, ILL.

NEW BOYLE'S LAW APPARATUS.

G. E. Ripley,
Fayetteville, Arkansas, University of Arkansas.

Boyle's Law like Ohm's Law is one of the experiments in physics that is never "overlooked" in laboratory work for students taking secondary physics or general college physics. Both laws are easy to prove provided the apparatus is in good condition and works all right but—the writers' experience has been that Boyle's Law apparatus more often gives trouble than it gives "P. V. equals a constant." We believe that more mercury is lost or damaged by this experiment than by any other three experiments in general laboratory work. This makes the experiment a costly one. The writer has used every kind of Boyle's Law apparatus that he has heard about and he has tried many that he wishes he had never heard about, seen described or much less purchased.

Several times the writer has worked out different ideas for apparatus for this experiment but they always had some bad effect like those already on the market. However, at last a simple form took shape and has proved more than satisfactory. Like most discoveries it is simplicity itself, yet it is this very simplicity that makes it so valuable for this experiment. We have been using it now for two years with our freshmen students and in all this time we have not lost five grams of mercury and a leak is impossible. We have had about one hundred fifty students a year who handle this apparatus and when we are through with the experiment the apparatus is just as good as when we started. Then while we can get a pressure from less than a quarter of an atmosphere to over two atmospheres very little mercury is used and no rubber tubing. This means an apparatus at very low cost and with no repair from one year to the next. Our tubes now are in as good working condition as they were at first with the exception of a slight oxidation of the mercury.



The drawings show how the apparatus works. A number of trials with tubes of different diameters proved that tubes with an internal diameter of about two millimeters were most satisfactory. The greatest trouble was to find tubes with anything like uniform bores. Twenty-four tubes were tested before three satisfactory ones were found. When these three were carefully calibrated they showed changes in the bores great enough to account for the errors in the P. V. product. Tubes which

appeared uniform when tested would vary over ten per cent in the diameters of the two ends. In most cases the tubes would swell or contract slowly from one end to the other, depending upon the end first tested while in other cases marked changes would appear along the tube. In the first tube used no calibration was performed and results for P. V. always increased as the volume of the gas was increased. Later the bore of this tube was tested and it was found that the diameter gradually became less from the closed end. This of course made the volume or rather length which was used for volume increase too rapidly. The tubes now in use are not free from variations in internal diameter but in most cases the error is small. Anyone desiring to try out the apparatus should calibrate their tubes before filling with mercury and sealing the one end.

The apparatus is mounted as shown in drawings a and b so that it may be rotated about the pivot p, which is placed near the center of mass of the system. If mounted upon an axis normal to the wall of the laboratory and about five inches from the wall where it is not in the way it will be found very convenient. A wing nut will hold it in position at any desired place. A horizontal shelf just low enough for it to clear makes measurements of H_c and H_o very easy.

The inside of the square made from two meter sticks was grooved for holding the glass tube. The stick used on the open end of the apparatus, however, does not need to be graduated. The tubes used varied from one hundred sixty centimeters to one hundred eighty centimeters long. The right angle bend was made slightly nearer the end left open so as to give more pressure.

We are using the apparatus on a laboratory table supported by a laboratory stand and clamped so that it may be roated and also moved up and down.

Our students enjoy the experiment very much and it gives very good results, the value of P. V. for pressures from about 20 centimeters of mercury to over 150 centimeters running about as follows:

P. V.	2753.75	2763.01	2760.43	2757.83
	2759.08	2763.56	2757.63Mean P. V2759.44	

ARTICLES IN CURRENT PERIODICALS.

American Forestry, for February, *Washington*. $4.00 *per year*, 40 *cents a copy*. "The Vanishing Trail," Arthur N. Pack, six illustrations; "Sherlock Holmes of the Forests," ten illustrations; "Trees in Winter," Henry T. Stephenson, nineteen illustrations; "The Royal Palm," Hollister Sage, five illustrations; "Forest Recreation Department—A Federation of Outdoor Clubs," Arthur A. Carhart, seven illustrations; "Broad-Leaved Evergreen Shrubs for the South," F. L. Mulford, nine illustrations; "Badgers and Wolverenes," R. W. Shufeldt, eight illustrations.

American Journal of Botany, for January, *Brooklyn Botanic Garden*. $6.00 *per year*, 75 *cents a copy*. "Ecological Relations of Plants in Southeastern Missouri," J. C. Th. Uphof; "Methods of Healing in Some Algal Cells," Susan P. Nichols; "The Present Status of Scolopendrium in New York State," Mabel R. Hunter; "Biophysics as a Point of View in Plant Physiology," Howard E. Pulling.

Popular Astronomy, for February, *Northfield, Minn.*, $4.00 *per year*. "Drake University Municipal Observatory," with Plates II and III, D. W. Morehouse; "Larger Worlds," F. R. Moulton; "The New Electric Driving Clock of the Photographic Telescope of the U. S. Naval Observatory," with Plates IV to VII, George H. Peters; "How to Look at the Moon," Julian L. Coolidge; "A Few Facts for the Meteor Observer," Rufus O. Suter, Jr.; "A Memorial to Elias Colbert," with Plate VIII, Charles H. Taylor; "Silvering Mirrors," with Plate IX, Edward S. King; "The Thirty-Eight Stars Having Largest Known Parallaxes," Carl L. Stearns; "The American Section of the International Astronomical Union," Joel Stebbins.

School Review, for February, *University of Chicago Press*. $2.50 *per year*, 30 *cents a copy*. "The Selective Principle in American Secondary Education. II," George S. Counts; "Current Practice in the Organization and Administration of Junior High Schools," J. A. Clement; "Oppor-

tunities for Correlation between Community Life and English. II," Howard C. Hill; "Psychology of the High School," Harold Johnson; "How Simplified Spelling Might Simplify," John A. Lester; "A History Chart," C. LeR. Hudelson; "The Relative Standing of Students in Secondary School, on Comprehensive Entrance Examinations, and in College," Bancroft Beatley.

Scientific Monthly, for March, *Garrison, N. Y.* $5.00 *per year*, 50 *cents a copy.* "The Problems of the Tide," H. A. Marmer; "The Organism and its Environment," Dr. Francis B. Sumner; "Control of Propaganda as a Psychological Problem," Edward K. Strong, Jr.; "Public Heath and Experimental Biology," Harry B. Torrey; "The Conservation of the Mammals and Other Vanishing Animals of the Pacific," Dr. Barton W. Evermann; "The Dawn of the Cell Theory," Professor John H. Gerould; "Japanese Influence in Chinese Medical Education," Dr. E. V. Cowdry; "A Curious Mathematical Title-Page," Professor F. Cajori.

The School, for March, *University Toronto, Toronto, Canada.* $1.50 *per year*, 20 *cents a copy.* "Agricultural Nature Study," David Whyte; "The Rural School Library," Adrian Macdonald; "Music in Public Schools," A. T. Cringan.

Torrya, for November-December, 7 *Robbins Place. Yonkers, N. Y.* "Cape Cod Vegetation," Roland M. Harper, "Observations on the Spores of Schizophyllum Commune," J. F. Adams.

BOOKS RECEIVED.

Measuring Minds, by Caroline E. Meyrs and Garry C. Meyrs, Cleveland School of Education. Pages 55. 13½ x 18½ cm. Cloth. 1921 Newson & Company, Chicago.

Questions and Problems in Chemistry, by Floyd Dral, Polytechnic Preparatory Country Day School, Brooklyn. Pages VII + 177. 13 x 18½ cm. Cloth. 1921. Harcourt, Brace & Company, New York City.

Health and Efficiency, by John D. McCarthy, DeWitt Clinton High School, New York City. Pages VIII + 262. 13 x 18½ cm. Cloth. 1921 Henry Holt & Company, New York City.

Carnegie Foundation for The Advancement of Teaching Sixteenth Annual Report of President and Treasurer. Pages 204. 18½ x 22 cm. Paper. 1921. 522 Fifth Avenue, New York City.

The Place of the Elementary Calculus in the Senior High School Mathematics, by Noah B. Rosenberger, Teachers' College, Columbia University. Pages VII + 81, 15.5 x 23 cm. Cloth. 1921. Teachers' College, Columbia University, New York City.

Proceedings of the High School Conference, University of Illinois, November, 1921, by H. A. Hollister, 401 pages. 15.23 cm. Paper. 1922. University of Illinois, Urbana.

Annual Report of the President of Columbia University for 1921. 62 pages. 15 x 22.5 cm. Paper. 1922. Columbia University, New York City.

Publication of the United States Bureau of Education:

Agricultural Education, by C. D. Jarvis. Bulletin No. 40. 26 pages.

Proceedings of the Fifth and Sixth Annual Meetings of the National Council of Primary Education. Bulletin No. 47. 44 pages.

Educational Survey of Wheeling, West Virginia. Bulletin No. 28. 53 pages.

The Work of the Bureau of Education for the Natives of Alaska. Bulletin No. 35. 12 pages.

Education in Forestry. Bulletin No. 44. 70 pages.

Education Survey of Elizabeth City, North Carolina. Bulletin No. 26. 43 pages.

Foreign Criticism of American Education, by W. J. Osbum. Bulletin No. 8. 158 pages.

BOOK REVIEWS.

Health Efficiency, by John D. McCarthy, DeWitt Clinton High School. Pages VIII−262. 13½ x 19½ cm. Cloth. 1921. Henry Holt & Company, New York City.

This is a splendid book written by a man who is thoroughly familiar with the subject, and has been written primarily for the use of pupils in high schools. It presents the fundamental principles of hygiene and sanitation in a simple and clear manner. It is well illustrated. It teaches the vital points, those with which all high school pupils should be familiar. The author goes on the supposition that study and care of the body is of more consequence than a detailed study of its anatomy. It is a book which deserves the careful study of all instructors who have anything to do with the health of their pupils. Mechanically it is well made, printed on a good quality of paper and is a book that should be in the hands of all science teachers.

C. H. S.

Measuring Minds, by Caroline E. Meyrs and Garry C. Meyrs, Cleveland School of Education, Cleveland, Ohio. Pages 55. 14 x 19 cm. Cloth, 1921. Newson & Company, New York City.

This manual has been prepared with the expectation that it will aid all who wish to make use of the intelligent ratings. In the manual are presented some tables and graphs which the authors give to prove that their system of tests is a good one. General and specific directions are given for securing the tests. It is a little book that all teachers should possess in order that they may carry out some of these tests in their classes, thus being able to tell how to classify their pupils.

C. H. S.

Carnegie Foundation for the Advancement of Teaching, 16th Annual Report of the President and Treasurer. Pages VI−205. 19 x 25½ cm. Paper. 1921. Carnegie Foundation, 522 Fifth Avenue, New York City.

This splendid report goes into details as to how the money of the Foundation was spent during the year ending June 30, 1921. There is a list of the people to whom pensions have been given. Also the list of the institutions, together with the amounts that have been allowed these institutions since the beginning of the Foundation's expenses. The relation of medical education to medical progress is discussed in a very admirable way, showing the closer relation existing between the American College of Surgeons to hospitals and medical teaching. It shows how the development of the National Board of Medical Examiners has improved the examinations that are now admitted to members in more than twenty states. It discusses in a very clever way the standing of the various medical schools and hospitals throughout the country. A large portion of the report is given to discussing legal education. As they have done before the report, shows what has been done in the development of the various pension plans. A splendid discussion being given here. The report is of such an interesting character that all college men ought to be interested in reading it.

C. H. S.

Methods of Teaching Vocational Agricultural in Secondary Schools, by Samual H. Dadisman, University of California. 142 pages. 12½ x 19½ cm. Cloth. 1921. The Cooram Press, Boston, Mass.

This unique and splendid text is the outgrowth of the authors experience in the supervision of vocational agriculture. The information then is ripe. It has been written to better aid teachers in vocational agriculture. It is not based on theory alone but on real and practical points. There is some history of vocational education given. It bears down hard

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on the fertility of the soil and the reasons for understanding thoroughly what elements are contained in the soil in order to raise the best possible crops. The project method of teaching is splendidly illustrated. It is printed on uncalendered paper thus avoiding the glare of reflection in reading. There are fifteen chapters and a splendid index. It is well worth while reading.

C. H. S.

Calculus and Graphs, by L. M. Passano, Associate Professor of Mathematics in the Massachusetts Institute of Technology. Pages VIII + 167. 13 x 19 cm. 1921. The Macmillan Company, New York.

For a short course to give students of physics, chemistry, engineering and medicine, a working knowledge of calculus, this book is worthy of favorable attention. As no knowledge of analytic geometry is assumed the fundamental ideas of the subject are presented in the first chapter. The student learns to use both algebraic and geometric methods in the study of functions and becomes acquainted with the forms of equations of simple curves as they are required in the solving of problems. Omitting the differentiation and integration of complicated forms and topics of little practical value, there is given a selection of real problems in rate of change, velocity, maxima and mimina, areas, volumes, pressure of liquids, center of gravity, mean value, work, and so on, with simple and concise explanations and discussions, which almost force the student to understand what he is doing.

H. E. C.

General Science Instructions in the Grades, parts 1 and 2 by Dr. Haner H. Webb. 105 pages. 15 x 23 cm. 1921. Peabody's College for Teachers, Nashville, Tenn.

This is without question one of the most complete and comprehensive of analyses of the general science situation that has ever been published. Dr. Webb has evidently made a thorough study of the situation including all of the texts that have been written upon the subject. Without getting into the real analysis of the book, it is sufficient for the reviewer to say that any person wishing to know about the present status of the development of general science teaching or anything concerning the relative amount of subject matter as divided between the various sciences cannot do better than to secure a copy of this report.

C. H. S.

Causes and Preventions of Fires and Explosions in Bituminous Coal Mines, by Edward Steidle. 75 pages. 14½ x 23 cm. Paper. 1920, Government Printing Office, Washington, D. C.

This is a most comprehensive report of the causes and preventions of fires and explosions in soft coal mines that has ever been written. It is well known that the miner's safety depends very largely upon his obeying the rules governing coal mining operation. The "safety first" campaign among miners was developed by the Bureau of Mines. The number that have been killed by coal mine explosions either by gas or dust is enormous, and most of these explosions can be traced to carelessness on the part of some miner. There has been a remarkable decrease in coal mine accidents since the principles given in this book have been put into operation. It is most profusely illustrated, there being 117 halftone illustrations of the various phases of mine operation given. It is a book that every one interested in or having anything to do with soft coal mining should have in their possession.

C. H. S.